

SUMMARY REPORT  
OF THE  
MINES BRANCH  
OF THE  
DEPARTMENT OF MINES  
FOR THE CALENDAR YEAR ENDING DECEMBER 31  
1919

*PRINTED BY ORDER OF PARLIAMENT.*



OTTAWA  
THOMAS MULVEY  
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1920







*To His Excellency The Duke of Devonshire, K.G., P.C., G.C.M.G., G.C.V.O., etc.,  
etc., Governor General and Commander-in-Chief of the Dominion of Canada.*

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII, chapter 29, section 18, Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1919.

(Signed)

Arthur Sifton,

*Minister of Mines.*



HON. ARTHUR SIFTON,  
Minister of Mines,  
Ottawa.

SIR,—I have the honour to submit herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1919.

I am, Sir, your obedient servant,

(Signed) Charles Camsell,

*Acting Deputy Minister.*



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## SUMMARY REPORT

OF THE

### MINES BRANCH OF THE DEPARTMENT OF MINES FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1919.

#### INTRODUCTORY.

The cessation of hostilities in the closing months of the year 1918, had a marked effect on the mineral production of Canada. The demand for minerals needed in the production of munitions and materials for war purposes having ceased, and this condition being immediately followed by a period of inactivity before readjustment and reconstruction could take place, contributed, to a large extent, to the decrease in the mineral output for the year 1919.

The Mines Branch has, however, during the year, continued its several activities to the fullest extent that could be accomplished with the present complement of technical officers.

The investigations undertaken in the field, consisted of examinations of both metallic and non-metallic deposits; while the work assigned to the several physical, chemical, and testing laboratories located at Ottawa, covered a wide scope, including the examination of, and reporting upon, mineral specimens, and the testing of ores, metals, fuels, oils, and gases. Supplementary to this class of work, mention might be made of the assistance given by way of technical advice to mining companies, prospectors, and others connected with the general mining industry of the country, in the solution of the technical problems and difficulties encountered during mining operations; or, on their application for information concerning certain mineral districts.

During the course of the year several publications were issued for general distribution, including the usual statistical reports, together with several special technical reports, all of which may be had on application.

Reference to the reports issued, and to the special work done by the different officers of the several divisions of the Mines Branch, will be found in subsequent sections of this annual Summary Report.

#### ORE DRESSING AND METALLURGICAL DIVISION.

During the progress of the war the work of this Division was confined, primarily, to those minerals which entered into the manufacture of munitions. On the cessation of hostilities, this class of work—which was, for the most part, of a commercial character—was discontinued, and the laboratories have been used entirely for the purpose of testing Canadian ores and minerals of economic interest. The report by the acting chief and officers of the Division with regard to the actual work undertaken during the year, is to be found on pages 54-59.

During the year the technical staff of the Division was depleted by resignations, the Chief Engineer and two chemists leaving the employ of the Government to accept more remunerative positions with private commercial concerns. The depletion of staff had the effect of curtailing a large amount of important work which otherwise would have been carried on.



## FUELS AND FUEL TESTING.

On account of the disorganization of this Division through resignations of certain members of the staff, it has been impossible to carry to completion investigations which had been planned.

During this year Mr. Ross E. Gilmore, who was in charge of the research work on low temperature carbonization and briquetting of fuels; and Mr. Thomas W. Hardy who was in charge of gas analyses and other work, resigned; and it was impossible at the salaries offered to fill their places. The special work they were conducting was consequently very greatly hampered, and in certain cases discontinued altogether.

In addition to the above depletion in the chemical staff of the Division of Fuels and Fuel Testing, the services of the Chief Engineering Chemist, Mr. Edgar Stansfield, have been lost to a large extent through his association with the Lignite Utilization Board, to which he has been attached as Chief Chemist, hence the work of the Chemical Laboratories was seriously handicapped.

The research work concerning the distillation of the oil shales of New Brunswick and elsewhere, was begun; but on account of the above depletions in the staff, the difficulty of filling vacancies, and of obtaining additional assistants, the work of investigating the samples of oil shale collected by Mr. Wright, of the Geological Survey, was seriously retarded.

A large part of the time of Mr. John Blizzard and Mr. E. S. Malloch was devoted to the preparation of a report on forty-one steaming tests, and producer gas tests for the press. Mr. Blizzard also did considerable work in connexion with a report on powdered fuels, which he was preparing to write.

Mr. Malloch, in addition to his regular routine work, made a number of pyrometer calibrations, and carried out certain determinations of tensile compressive strength and hardness, on samples of steels.

The Chief of the Division of Fuels and Fuel Testing, in addition to his regular duties as Chief of that Division, devoted a large amount of his time to the Peat Committee—of which he is secretary—also to the Dominion Power Board. Moreover, he prepared during the course of the year a number of special reports on fuels.

The staff of the machine shop was continually occupied in constructing new apparatus, erecting new, and repairing existing machinery.

## METALLIFEROUS MINES DIVISION.

The investigation of pyrites deposits—undertaken during the previous year by Dr. A. W. G. Wilson, Chief of the Division—was continued, about two months being spent in Ontario and Quebec visiting reported occurrences of pyrites.

The balance of the year Dr. Wilson was engaged in completing his report on potash recovery at cement plants, which work was undertaken at the request of the War Trade Board. The report was published early in the year, and the demand for it was such that the edition soon became exhausted. In addition, the Chief of the Division devoted his attention to the preparation of an extensive report on the Development of the Metallurgical and Chemical Industries of Canada, which publication it is expected will be ready for distribution some time during the current year.

The services of Assistant Engineer, Mr. A. H. A. Robinson, were loaned to the Ontario Bureau of Mines, to make certain magnetometric surveys in the vicinity of Windy lake, Sudbury district. Later in the season, Mr. Robinson investigated certain titaniferous iron ore deposits. The preliminary report of the work done by this official may be found on page 13.



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## INVESTIGATION OF MINERAL PIGMENTS.

Large quantities of minerals are used by paint manufacturers; and although a considerable amount of these are furnished from domestic sources, it is found that a considerable supply is brought in from other countries.

The investigation was undertaken to prove up the deposits of mineral pigments throughout Canada, with a view to directing users of this commodity to sources of domestic supply, so that they might avail themselves of the Canadian product instead of depending upon importations.

Mr. Howells Fréchette was assigned to this work, and his report of the field season's activities in this connexion is detailed on pages 17-19.

## INVESTIGATION OF CERTAIN NON-METALLIC MINERALS.

Mr. H. S. Spence was commissioned to secure data on deposits of talc, soapstone, barytes, celestite, and strontianite. Field work was confined to Ontario, Quebec, and Nova Scotia.

A preliminary report on the localities visited in carrying out, during the season, the work assigned, may be found on page 19.

## CHEMICAL LABORATORIES.

The general mining public have taken full advantage of the facilities offered by the Mines Branch chemical laboratories for assistance in connexion with the development of the mineral resources of Canada. The usual variety of work was undertaken, and completed; a considerable quantity of the material treated being furnished by Mines Branch officials, as well as by officers from other government departments, also by mining concerns, prospectors, and others.

In addition, considerable work of a research character was assigned, the services of the depleted staff of chemists being severely taxed to keep abreast of the several investigations. The report of the Chief Chemist appears on pages 27-30.

## DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.

The business done at the Assay Office during the year 1919 compared quite favourably with that of former years; the amount of gold bullion deposited exceeding that of any previous season, with the exception of the year 1918. The policy of shipping to the Royal Mint at Ottawa all the gold bullion purchased at the Vancouver office was continued.

The deposits made at the Assay Office during the year totalled 1,391, and came from British Columbia, Yukon Territory, Alberta, and Alaska, the net value being \$3,547,524.93.

The practice of purchasing platinum was discontinued at the beginning of the year; but it was decided to still give assistance to the prospectors, by continuing to accept platinum ores and sands for treatment, and thus assist in marketing the refined product, locally.

## DIVISION OF MINERAL RESOURCES AND STATISTICS.

During the year the staff of this division has been occupied, for the most part, in collecting data relative to the mining and metallurgical industries of Canada, and in preparing the Preliminary and the Annual Mineral Production reports, and, in response to special inquiries, numerous memoranda, relating to our mineral resources and mining activities, were prepared and sent out.



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Furthermore, the division keep in close touch with the production of certain important mineral products, such as iron and steel, coal, chromite, sulphuric acid, etc., by compiling a monthly or quarterly record of the output of these materials. The former arrangement with the Department of Trade and Commerce, whereby the completed files of our Statistical Division were made accessible to the Dominion Bureau of Statistics, was continued throughout the year.

In a succeeding section of this Summary Report is to be found a more completed record of the work of the division submitted to the Chief Statistician.

### CERAMIC DIVISION.

The work of this division covers a wide scope; since not only does it concern itself with investigating the available deposits of raw materials that enter into the ceramic industries, but must meet the growing demand for information with regard to the various finished clay products.

Because of the difficulty in securing duly qualified technical assistants, very little research work could be undertaken, the limited staff being fully occupied with routine work, and the answering of inquiries relative to the clay and shale resources of the country.

In addition to the usual laboratory investigations, the work of the division during the year consisted in making a survey of the structural materials deposits in a portion of the St. Lawrence River valley, and an examination of deposits of high-grade clays, in northern Ontario.

References more or less in detail to the work of the division as carried out by the chief engineer and his assistants are given in a succeeding section of this report.

### ROAD MATERIALS DIVISION.

Work on the general problems which have been undertaken by the Road Materials Division was continued during the year. The Chief of the Division spent part of his field season in Manitoba, where an investigation of materials available for rural road construction in a typical prairie area is being conducted. This work has developed primarily into a study of aggregates composed of the various natural soil types, modified by admixture of sand or gravel, or by some other form of treatment, with a view to producing—with the materials at hand, under prairie conditions—an aggregate that will give serviceable results in a rural road-bed or surface. Time was also spent, in response to requests from officials of the Department of the Interior, at Rocky Mountains Park. A similar road material problem exists in the mountainous country, where it is necessary to secure stable aggregates by the utilization of the variable types of material encountered in establishing the road grades along the steep mountain sides.

The problem of developing the general method of conducting material surveys, and of sampling and testing road materials—the problem which has been presented to the Road Materials Division in conducting work in Ontario and Quebec—was continued by Messrs. Gauthier and Picher. A section of the route from Toronto to Montreal was examined in detail, and some miscellaneous work in surveying and sampling completed.

The Road Materials Laboratory has been working to capacity conducting tests and investigational work which are supplementary to the field work of the Division.

### TECHNICAL LIBRARY.

During 1919, the Library has been broadened very appreciably; for not only have many new and desirable publications of interest to the various Divisions of the Mines



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Branch been secured; but, in addition, very valuable files of technical publications suited to the requirements of the Road Materials Division have been assembled.

Many of the most important technical institutions of Europe, which suspended activities during the war, have reorganized, and the Library, which is used as a "laboratory," has benefited intrinsically by receiving the publications of these institutions, which constantly do service in investigation work.

A number of recent trades catalogues, which have proved to be an indispensable factor toward keeping the Mines Branch staff informed as to the latest analytical and metallurgical instruments and methods, have been secured.

## Accessions for the year:—

Books (by purchase) .. . . .	98
Books (by gift) .. . . .	35
Books (bound) .. . . .	194
Canadian Government documents (by exchange) .. . . .	604
Foreign Government documents (by exchange) .. . . .	1,307
Scientific Institutions Proceedings (by exchange) .. . . .	517
Pamphlets (by gift) .. . . .	107
Trades Catalogues (by gift) .. . . .	58
Maps (by exchange) .. . . .	77
Total accessions for 1919 .. . . .	<u>2,997</u>

(Signed) Eugene Haanel,  
Director.



## INDIVIDUAL SUMMARY REPORTS.

### METALLIFEROUS MINES DIVISION.

#### I.

ALFRED W. G. WILSON, *Chief of Division.*

This division employed only two permanent officers for field service, and one library assistant, during the year 1919.

Mr. A. H. A. Robinson devoted the whole of his time to work relating to iron ore deposits. In the month of March the services of this officer were loaned to the Ontario Bureau of Mines to assist on the geologic mapping of an area in the vicinity of Windy lake, Sudbury district, by means of magnetometric surveys of areas below the level of the lake. The summer field season was devoted to an investigation of our titaniferous iron ore resources. Mr. Robinson's preliminary report on this work is attached hereto.

Dr. Alfred W. G. Wilson, chief of the division, devoted only a portion of his time to work of this division. In addition to routine office work—which included the preparation of a number of replies to inquiries relating to the mining and production of metals and ore, and to questions in non-ferrous metallurgy—about two months were spent during the field season in central Ontario; and in Quebec during the months of September, October, and November, visiting reported occurrences of pyrites. Additional information was obtained for office use and for incorporation in a second edition of the report on "Pyrites and its Uses." The greater portion of Dr. Wilson's time during the year was devoted to work arising from his investigations during the war period, in the preparation of reports on potash recovery at cement plants, and development of the metallurgical and chemical industries of Canada.

An investigation of the processes in use in the United States in cement plants, for the recovery of potash salts from waste flue gases, was undertaken in 1918, on the initiative of the War Trade Board. The field work in connexion with this investigation was not completed until December, and the report was prepared early in the year. The completed manuscript was sent to the printer in May, and the Report on Potash Recovery at Cement Plants was issued in July, 1919. Dr. Wilson also delivered illustrated addresses on this subject before the Toronto Branch of the Society of Chemical Industry, and before the Montreal Metallurgical Society. The Canada Cement Company is installing potash recovery equipment at the Port Colborne (Ontario) plant. It is expected that this equipment will be in operation in June, 1920. An unexpected demand for this report exhausted the supply within six weeks of issue. The complete report was republished by a technical journal in the United States, and by another journal in Great Britain. The main portion of the report, based on Dr. Wilson's address in Toronto, was also published in the Journal of the Society of Chemical Industry, so that, in effect, four editions of this report were published within four months of issue.

Progress has been made in the preparation of a very extensive report on the development of the metallurgical and chemical industries in Canada. This report will deal with the principal industries using minerals or chemicals and other products made from minerals. A comprehensive survey of Canadian metallurgical and chemical



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industries has been made, to ascertain what raw materials are required; where these supplies originate; and where the finished products are marketed. It is thought that, in some cases, native raw materials can be substituted for imported supplies, and there are finished products that might well be made in Canada. This report, and the information it will contain, should facilitate the further development of our natural resources, and should contribute to the expansion of home industries.

The library research work in this division has been maintained throughout the year by Miss D. M. Stewart. An extensive index of metallurgical and chemical products made in Canada, and a directory of the uses of raw mineral products has been compiled for use in the Report on the Development of the Metallurgical and Chemical Industries in Canada.

## II.

## INVESTIGATION OF IRON ORE DEPOSITS IN NORTHERN ONTARIO.

A. H. A. ROBINSON.

The winter months of 1919 were spent in the usual routine office work, viz., the preparation of reports and maps, answering inquiries about iron ores and the iron industry, abstracting and filing information concerning Canadian iron mines and iron ore deposits, etc.

In March, at the request of the Ontario Bureau of Mines, a magnetometric survey was made on the ice at Windy lake, in the Sudbury nickel area; where it was hoped magnetic indications might be found that would lead to the discovery of hidden deposits of nickeliferous pyrrhotite along the granite-norite contact that is here covered by the lake and by sand hills. Had the magnetometric survey indicated the probable presence of pyrrhotite, it was the intention of the Bureau of Mines to explore the lake bottom by diamond drilling. No abnormal magnetic disturbance was found in the neighbourhood of the lake, however, and, investigations by Bureau of Mines geologists having also failed to discover any indication of the presence of ore bodies, the proposed drilling was not undertaken.

The summer and autumn months were spent in a field investigation of titaniferous iron deposits in Canada, and in visiting, for the purpose of noting recent developments, the iron ore districts in northwestern Ontario, in the vicinity of Sault Ste. Marie, Sudbury, and Port Arthur.

## TITANIFEROUS IRON ORES.

In Canada, all the known deposits of titaniferous iron ore of any considerable size or importance are to be found in the provinces of Quebec and Ontario. These deposits first attracted attention as possible sources of supply for iron furnaces, and several unsuccessful attempts were made in years past to establish local iron industries based on their use. Later, with the increasing demand for titanium in various industries, the deposits richer in that metal acquired a value for their titanium contents, irrespective of the iron. Still more recently, the fact that vanadium, in minute quantities, is often found associated with the titaniferous iron ores, has led to an investigation of the possibilities of such ores for the commercial production of vanadium, or vanadium steel.



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In the province of Quebec, there are—in addition to a number of points of minor interest—four widely separated localities in which large and important bodies of titaniferous iron have been found. They are: Ivry-on-the-Lake, Beresford township, Terrebonne county; St. Urbain, in Charlevoix county; Bourget township, in Chicoutimi county; and at the Bay of Seven Islands, on the north shore of the lower St. Lawrence.

At St. Urbain and Ivry, at both of which places the ore is ilmenite, carrying 18 per cent and upwards of titanium, the deposits have been worked more or less intermittently—St. Urbain since 1910, Ivry since 1912. Most of the material shipped has gone to Niagara Falls, N.Y., to be used in the production of ferro-titanium, but any large or continuous production for this purpose has been hindered by the competition of high grade rutile and ilmenite concentrates from Virginia and Florida. In one of the deposits at St. Urbain, there is in addition to ilmenite sufficient associated rutile to give the deposit the distinction of being the only known occurrence of rutile in commercial quantity in Canada, and one of the four or five recorded occurrences in commercial quantity in the world.

The deposits in Bourget township, and those at Bay of Seven Islands are titaniferous magnetite, carrying for the most part less than 15 per cent titanium and about 50 per cent iron. They are in the unfortunate position of carrying too little titanium to have value as titanium ores, but too much to find favour as iron ores. Practically no development has been done in the deposits at either of those places.

In Ontario, so far as is known, all the deposits of magnetite large enough to be of possible economic importance are mostly titaniferous; and, like those in Bourget township, and at Seven Islands, in Quebec, are, in their natural condition, too low in titanium for titanium ore, and too high for iron ores. The most extensive of the Ontario deposits are those that have been traced by their outcrops, and by means of dip needle readings for a distance of 12 or 14 miles along the north shores of Seine bay and Bad Vermilion lake, in the Rainy River district. Diamond drilling has shown that they extend vertically with undiminished thickness, in at least one place, to a depth of nearly 500 feet below the highest outcrop. The better grades of the Seine Bay ore will run between 40 and 50 per cent in iron, with titanium in some cases as high as 15 per cent.

Less extensive deposits occur in numerous other localities throughout Ontario, among those more generally known are: the Matthews and Chaffey mines, in Leeds county, which were worked as iron mines in the sixties and seventies of the last century; the Orton mine, in the townships of Tudor and Lake, Hastings county, small shipments from which were used experimentally in the production of tool steel direct from the ore; and the so-called Pine Lake or Pusey mine, in the township of Glamorgan, Haliburton county. In much of the literature dealing with titaniferous iron deposits in Canada, the Pine Lake deposit is referred to as being one of the largest and most important: an assumption apparently based on incomplete investigations, or even on hearsay evidence, that is not borne out by recent investigations. A surface examination of the area—the deposit is entirely undeveloped—leads to the conclusion that the titaniferous magnetite here, like that at the Orton mine, 34 miles to the southeast, does not form one large continuous body, as was assumed, but consists of comparatively small, ultra-basic segregations, irregularly scattered through a mass of black, basic, igneous rock that on casual inspection might be mistaken in large part for magnetite. A sample of the richest looking material that could be found yielded only 31 per cent iron and 7.54 per cent  $\text{TiO}_2$ .

As regards the outlook for the utilization of the titaniferous ores, those high in titanium, like the ilmenites at St. Urbain and Ivry, have been, to some small extent, mined for export to the United States, as ores of titanium, and were it not for the competition of higher grade ores from Virginia and Florida, there would no doubt



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be a steady demand for the Quebec product. Up to the present there has been no domestic market for such ores. With the increasing use of titanium and its compounds, it is not unreasonable to expect that the Quebec ilmenite deposits will sooner or later be in greater demand either at home or abroad.

The outlook for the titaniferous magnetites is more doubtful. Ore of this class was formerly smelted, like ordinary titanium-free magnetites, in charcoal blast furnaces in Norway, Sweden, England, and the eastern United States; and trial runs in a modern coke blast furnace, extending over sufficient periods of time as to leave little doubt as to the accuracy of the results obtained, appear to have clearly demonstrated that when suitably fluxed and smelted under proper conditions of temperature and pressure of blast, they are as easy to smelt as titanium-free magnetites. Nevertheless their use for iron-making has ceased entirely, and they are now in hopeless disrepute with blast furnace men. Leaving out of consideration for the moment their titanium content, there are also other possible reasons why greater interest has not been shown in the efforts made to promote their use. They are only low to medium grade in iron content, and would usually require concentration before they could be used in the blast furnace. Furthermore, the mode of occurrence of most of the deposits is not such as to render them amenable to the most economical methods of mining, and the production of the large and steady output demanded by modern blast furnace practice.

In some quarters, the introduction of the electric furnace has revived the hope of utilizing the titaniferous iron ores, either for the production of high class pig-irons, or for their direct reduction to high grade steel. Both pig-iron and tool steel have been successfully produced from titaniferous ores in an experimental way in the electric furnace, and it is quite possible that where conditions are favourable, local industries of this kind may yet be established. It is not clear, however, that even for this purpose, titaniferous ores will have any special advantage over equally available titanium-free ores, unless it is found possible—and also profitable—to recover titanium or vanadium as well as the iron.

The fact that titaniferous magnetites are to a large extent, if not entirely, made up of mechanical mixtures of ilmenite and magnetite, at once suggests the possibility of separating them magnetically into a high grade, non-magnetic, ilmenite product on the one hand, and titanium-free magnetic iron ore on the other. Efforts in this direction have met with only partial, but widely varying success. In some cases the proportion of titanium to iron can be brought low enough to make practicable the mixing of the concentrates with non-titaniferous ores, and thus render the titanium content negligible. It is also in some cases possible to obtain a high ilmenite product that would do for titanium ore; but to make a magnetite concentrate free from titanium has been found practically impossible, either on account of the extremely intimate intermixture of the ilmenite with the magnetite, or because a portion of the titanium is contained in the magnetite molecule itself.

## IRON ORE DEVELOPMENTS.

The Helen hematite mine in the Michipicoten district has been worked out, and was finally abandoned in April, 1918. This deposit furnished most of the native ore smelted in Ontario furnaces since it began to produce in 1900, and its passing marks the end of the largest body of high grade iron ore yet exploited in Ontario, or, for that matter, in Canada. The total production from the time the mine first shipped in 1900 until its abandonment in 1918, was, in round numbers, two and three quarter million tons of 2,000 pounds.

The siderite deposits that lie alongside the now worked out hematite body at Helen mine, and that were explored by diamond drilling in 1916 and 1917, have been



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opened up by an adit 890 feet in length, connecting with three main branches aggregating a further 800 feet in the ore body itself. The quantity of ore developed by these operations is very large, constituting probably the largest single reserve of iron ore yet developed in Canada. The Algoma Steel Corporation's engineer's estimate is that there are 100,000,000 tons in the whole deposit; 10,000,000 tons of which are above the tunnel level, and can be won without hoisting. The siderite, in its natural state, runs about 37 per cent of iron, and can be roasted, like the Magpie siderite, with which it compares favourably, to 50 per cent or better in iron. Owing to the high cost of labour and material the work still necessary to put these deposits on a producing basis was suspended in October, 1918, and has not since been resumed.

At the Moose Mountain mine in the Sudbury district large reserves of low grade magnetite, amenable to magnetic concentration, have been proved by diamond drilling and development work. Mining is confined to the No. 2 deposit, which has been opened up by means of an adit 10 by 11 feet in cross section and 350 feet long. Where it hits the ore body, the adit branches into two main drifts, one of which follows the foot wall, the other the hanging wall of the deposit for a distance of between 500 and 600 feet. The drifts then come together again, forming a loop for haulage. Stoping is carried on above both drifts. The ore is won partly by open pits, partly by shrinkage stoping, and is drawn from the stopes through chutes on the adit level. Mining is carried on in the shrinkage stopes during that portion of the year when climatic conditions make open cast working difficult and dangerous. Sufficient ore has been developed above the adit level to take care of all probable requirements for some years to come. The average iron content is about 35 per cent, which is increased to 60 per cent and over in the mill.

The concentrating mill is still operating on a more or less experimental basis, but all technical difficulties appear to have been overcome, and high grade briquettes—over 60 per cent iron with negligible amounts of phosphorus and sulphur—are being produced in quantity. Shipments of briquettes in 1918 amounted to 26,385 tons; when the plant was visited in September 1919, no shipments were being made, the output of the mill being stockpiled awaiting a favourable market.

As having a bearing on the outlook for financially successful operation at Moose Mountain, it is of interest to note that exhaustive experiments carried out on lean magnetites found at the eastern end of the Mesabi range, which appear to be very similar to the Moose Mountain magnetite, are said to have demonstrated the commercial feasibility of treating such material by magnetic concentration, and the announcement is made that a plant for this purpose, capable of handling 4,000 tons per day, will be in operation at Duluth before the end of 1920.

In the Thunder Bay district, Cleveland, Ohio, parties have undertaken to do some 5,000 feet of diamond drilling on the P. A. Leitch claims, on what is known as the Central Iron Range, east of Lake Nipigon. When the district was visited, in September, 1919, only 1,800 feet of this had been completed, and no authoritative statement of the results obtained was available.

Some diamond drilling, to fulfil the requirements of the Ontario Mines Act, regarding assessment work, was also done on the north side of Seine river at the outlet of Steeprock lake, west of Port Arthur. The surface showings consist of bands of rusty weathering carbonate, associated with greenstones and green schists, and small packets of limonite, from a few inches to a few feet in diameter. Considerable small float of fairly good hematite has also been found. So far as could be learned no merchantable ore was found in the drill holes.



## NON-METALLIFEROUS MINES DIVISION.

## I.

## IRON OXIDE PIGMENTS IN THE PROVINCE OF QUEBEC.

HOWELLS FRÉCHETTE, *Chief of Division.*

The paint manufacturers of Canada consume large quantities of minerals, many of which are procurable in the country. Although considerable domestic material is used at present, the proportion of imported is very large. It has been decided to prepare a bulletin on the mineral pigment resources of Canada, in order to show the available sources of supply of such minerals as are used in the paint industry. While fairly complete information concerning a number of the more important of these minerals is available, scattered throughout various departmental reports, there is little dealing with the iron oxide pigments.

During the field season of 1919, work was commenced in the Province of Quebec, on the examination of deposits of ochres.

Many deposits of ochre have been reported from various sections of the Province. Practically all of these, with the exception of certain remote deposits and those lying east of Quebec, have been visited, and, where it was deemed desirable, samples were taken for laboratory examination and testing. In the southern part of the Province no large deposits of ochre were seen, and but few that have any commercial possibilities.

## THREE RIVERS AND VICINITY.

The more important occurrences of ochre lie to the north of the St. Lawrence river. One group of such deposits is situated a short distance to the east of Three Rivers, between Cap de la Magdelaine and Champlain, about two miles north from the St. Lawrence. In this area, at Red Mill, the Canada Paint Company, Ltd., operates an extensive plant for calcining, washing, and grinding pigments from its deposits. A variety of shades of red, umber, and sienna are produced.

The plant and deposits of the Champlain Oxide Co. are about  $1\frac{1}{2}$  mile east of Red Mill. This company operates a calcining plant, which is situated near the deposits, and a grinding and packing plant beside the Canadian Pacific Railway tracks.

For a number of years Thomas H. Argall, of Three Rivers, produced calcined red oxide from his deposits two miles east of those of the Champlain Oxide Co. Owing to labour troubles, he closed his plant and transferred his business to Pointe du Lac, where he now ships uncalcined ochre for use in the purifying of illuminating gas. He obtains this material from a series of deposits lying about one mile to the north of his warehouse, which is beside the Canadian Pacific Railway tracks, nine miles west of Three Rivers.

About thirty years ago the Radnor Paint Company operated a calcining and grinding plant at Proulx, Champlain county. The crude ochre was obtained from rather irregular deposits along the beds of two small brooks which join and flow into the St. Maurice river a short distance south of Grandes Piles. This property is now owned by the Laurentide Company, of Grande Mere, and is within the area set aside by them for reforestation.



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To the south of the St. Lawrence river, in the sixth range of Gentilly, there is a rather extensive deposit of ochre between the base of a high sand hill and the Gentilly river. In places the ochre is rather sandy. Several years ago this deposit was worked to a limited extent by Ouellet and Thibaudeau. Two small calcining furnaces are all that now remain of the equipment. The deposits are situated six or seven miles from the railway and hauling had to be done over poor roads.

## PORTNEUF COUNTY.

About two miles to the southwest of St. Raymond, on the property of Remi Cayer, there is a deposit of ochre in a bog lying between the main road and the St. Anne river. This was worked on a small scale about 25 years ago by Piche and Allan. The bog, which is about four or five acres in extent, could be drained easily by means of a short ditch to the river bank. In places the ochre is very shallow, while elsewhere it exceeds six feet in depth. In general it is free from sand. This was the only deposit of any importance seen in this county.

## MONTMORENCY COUNTY.

On the property of Joseph Racine,  $1\frac{1}{2}$  mile west of the Taschereau-Parent bridge over the St. Anne de Montmorency river, and lying about a quarter of a mile north of the road, there is a deposit of ochre of considerable extent. In shape it is somewhat like an open fan and measures about 1,000 feet by 500 feet. The depth, where ascertained, was found to range from a few inches to a maximum of less than ten feet, the average being about three feet. The ochre, in some parts of the bog, is underlain by woody peat which could not be penetrated by the sampler. It is possible that this peat may, in turn, be underlain by more ochre. It has been stated that samples of ochre were obtained at a depth of twenty feet or more. It may be that misleading results were obtained through using an open pipe sampler. Much of the ochre is free from grit, though sand is carried into portions of it by small brooks and by the overwash in very wet weather. This property has never been worked.

## LABELLE COUNTY.

The Paint Products Co. of Canada, Ltd., has recently erected a large plant for washing, calcining, and grinding pigment at its ochre deposits on lot 18, range IV, Lynch township. The deposits are large and yield a variety of colours, both raw and calcined. In places the ochre is somewhat contaminated with sand, while elsewhere it is apparently free from grit. As yet only a preliminary examination has been made. It is said that between 25 and 30 acres are underlain by ochre. The maximum depth could not be determined, as it exceeded the length (12 feet) of the sampling drill.

While operating to a limited extent at the time of visit, in September, much of the work was still in the experimental stage. The nearest point of shipment is Annonciation, on the Mont Laurier branch of the Canadian Pacific Railway, which is distant fourteen miles by road.

## DRUMMOND COUNTY.

In the southern section of the Province, as already pointed out, no large deposits of ochre were seen. One, however, is worthy of mention. While from a hurried examination the quantity of ochre did not appear to be great, it is of decidedly good quality. When wet it is bright yellow, and when ground in oil after air drying it produces a very good tone of sienna with strong tinting power. This deposit lies along a small stream on the farm of R. W. Billingsley, on lot 4, range IV, Durham township, Drummond county.



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In addition to the deposits mentioned above, many of lesser importance were visited and sampled, in various sections of the Province, including the Ottawa valley as far west as Waltham.

The sampling was done by means of a drill designed especially for the purpose. It is similar to the regular open side scoop drill, but has a rotating shutter whereby the aperture may be closed while the drill is driven to the desired depth, opened to receive the sample, and again closed for withdrawing the drill. This drill was found to work well, and it is considered that the samples taken by it are truly representative of the material.

During the winter, the samples collected were tested in the laboratory to determine their worth as raw material for paint manufacture. A series of calcining tests was conducted under varying conditions of temperature and composition of atmosphere. A wide range of calcined colours were produced from the common "red oxide," to burnt umber and rich purples.

A full record of these tests will be included in the final report.

## II.

## INVESTIGATION OF MISCELLANEOUS NON-METALLIC MINERALS.

HUGH S. SPENCE.

The writer's field work consisted in gathering data on talc and soapstone, barytes, celestite, and strontianite, the territory covered including Ontario, Quebec, and Nova Scotia. In addition, fertilizer works in eastern Canada were visited, in order to bring up to date the information secured several years ago on the manufacture of artificial fertilizers in Canada. This information is required for a report on the phosphate deposits of Canada, which was prepared by the writer in 1915. The publication of this report was deferred during the war period, but it has now been decided to publish it, on account of the numerous inquiries that have been received by the Mines Branch for information respecting available supplies of phosphate in Canada.

In addition to examining deposits of the above-mentioned minerals, the writer visited a number of manufacturing plants using the minerals for industrial purposes, and gathered data regarding the requirements of the various industries.

The information secured is to be incorporated into separate reports on the minerals in question, which are to be published by the Mines Branch.

## TALC AND SOAPSTONE.

## ONTARIO.

The Canadian talc mining industry centres around Madoc and Eldorado, in Hastings county, Ontario, where there are at the present time three producing mines, each equipped with a grinding mill. These mills have a daily capacity of 80-90 tons of ground talc. The ore in each case is a white to cream crystalline talc, which grinds to a white powder that is much in demand for toilet purposes and paper-making. The talc occurs in the form of lenses in crystalline dolomite and is probably an alteration product of this rock. Quartz, dolomite and magnesite, in the form of grains and stringers, are the principal impurities in the ore, and the talc grades into dolomite at the borders of the lenses.



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At one of the mines, the talc body is bordered on the east by crumpled, grey talc schist, and a separate mill is being equipped to grind this material, which is stated to be of excellent quality for foundry facings and rubber products.

The grinding equipment at all of these plants consists of pebble mills, the product of which is either air-floated or (in one instance) passed through flour-mill type bolters and scalpers.

The operating companies are: Eldorado Mining and Milling Company, Eldorado; Anglo-American Talc Corporation, and Henderson Mines, Ltd., both at Madoc.

As already noted, the talc of the Madoc district possesses crystalline character. The ore consists of a mass of small, shapeless folia which are usually elongated in one and the same direction, thus imparting to the rock a schistoid character. Massive, compact talc does not occur here, but specimens of what appears to be a rather hard, impure soapstone were collected on the waste dump at one of the mines. This material has a greenish-grey colour, is quite compact and without grain, but lacks the greasy feel of good quality soapstone. Cubes of the material, burnt at 1,000° C., became creamy-brown in colour and very hard, but were found to have developed slight checks. It is questionable, therefore, whether the material would prove suitable for gas burners and tips.

#### QUEBEC.

Soapstone of better quality, as regards purity, is found at several localities in Quebec province. A small quantity has been mined on lot 23 in range IV of the township of Melbourne, Richmond county, on land owned by the New Rockland Slate Company. The soapstone body is only 1 to 2 feet thick, and occurs in a shear zone in a very much altered and decomposed rock. The soapstone is compact and grey-green in colour. It would probably be excellent material for lining-blocks for the calcining furnaces in pulp mills and for lava purposes, but unfortunately it is friable and breaks up very readily into thin sheets. Owing to this characteristic, and considering the narrowness of the deposit, the occurrence cannot be regarded as of economic importance.

Soapstone, similar to the above, occurs also on lot 26 in range II of the township of Bolton, in Brome county. This deposit has a width of 7 feet at the point where it has been opened up, and has been traced for 400 feet along the strike. The soapstone is of good quality but is extremely friable.

A band of impure, greenish soapstone, 12 feet wide, occurs enclosed in serpentine on lot 5 in range V of Thetford township, Megantic county. The material is friable and breaks up readily into paper-thin leaves.

On lot 20 in range II of the township of Wolfestown, Wolfe county, a deposit of soapstone was worked a number of years ago. The material is said to have found employment in paints, lubricants and foundry facings. The workings are now inaccessible and none of the ore is available for examination.

Numerous narrow veins or seams of talc, none of them exceeding 1 foot in width, occur on lot 2 in Craig's Road range of Ireland township, Megantic county. The talc has a green colour and occurs as aggregates of large flakes (crystals), often associated with large crystals of ankerite. The talc bodies grade off into chlorite and talc schists, which form the country rock. While interesting mineralogically, this occurrence of talc would not appear to possess economic importance.

Soft, greenish-white talc occurs in narrow bands, not exceeding 2 feet in width, on lot 1 in range I, township of Inverness, Megantic county. This lot adjoins the preceding property.

Soapstone and talc have been reported to occur at a number of other localities in or adjacent to the serpentine belt of the Eastern Townships; bands of impure soapstone, usually quite narrow, being not uncommon in the serpentine proper as well as



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in the altered basic intrusives (pyroxenites and chloritic, talc, and greenstone schists) associated with it. Many of the talc bands grade into talc or chloritic schist, and none of the deposits examined exhibited features that would warrant their being regarded as of particular economic importance. It is possible, however, that the friable soapstone at the localities listed above might give way in depth to a more massive and compact material.

None of the deposits have been actively exploited, shallow prospect pits representing the only development work. In view of the occurrence of important economic bodies of talc and soapstone, associated with similar rocks, in the adjoining state of Vermont, it is at least possible that closer investigation of the Quebec area would disclose larger deposits of these substances than those mentioned above.

## BRITISH COLUMBIA.

A deposit of soapstone occurs at the base of Mt. Whymper, near Vermilion Summit, 11 miles south of Castle station on the main line of the Canadian Pacific railway. The writer visited the locality in 1915, and found the soapstone to occur in several irregular pockets or chimney-like bodies, enclosed in a grey, horizontally bedded dolomite. All the soapstone bodies occur at approximately the same horizon in the dolomite. They vary in width from 15 to 20 feet, the maximum vertical extent being 75 feet. The soapstone usually contains an appreciable amount of quartz, both massive, as stringers, and in the form of small, well formed crystals. Crystals ofankerite also occur in it. These minerals appear to occur chiefly near the contact of the soapstone with the dolomite.

The soapstone has a light yellowish-green colour and is of good quality. Unfortunately, it exhibits a decided tendency to check, and a great proportion of the material collected around the outcrops was found to be badly flawed. Test pieces, after burning at 1000° C., were found to be too badly checked to be of any value for lava purposes. Whether this undesirable characteristic persists throughout the deposit is problematical. It is reasonable to expect that the material will be found to be more compact and less subject to flaws with increasing distance from the surface. Only prospecting work has been done on this property.

A small quantity of talc is reported to have been secured during 1919 near Marne, mile 92, on the Pacific Great Eastern railway. The material was shipped to Vancouver to be ground for use in surfacing roofing.

A deposit of soapstone is reported to have been worked during 1919 on Wolf creek, Vancouver island. Further particulars are lacking at the time of writing.

## Production of Talc.

The production of talc in Canada in 1919 was 18,642 tons, and practically the entire output came from the Madoc district, Ontario. The bulk of the talc finds employment in the paper and toilet products industries. The following table shows the annual production of talc since 1912:—

Year.	Tons.	Value.	Year.	Tons.	Value.
1912....	8,270	\$23,132	1916 .....	13,104	\$49,423
1913....	12,250	45,980	1917....	15,803	76,539
1914....	10,808	40,418	1918....	18,190	112,727
1915....	11,885	40,554	1919.....	18,642	116,295



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**BARYTES.****NOVA SCOTIA.**

The domestic output of barytes has been chiefly derived from the province of Nova Scotia, where deposits of the mineral occur at a number of localities. In recent years, practically the entire production has been secured from the deposits on the east side of Lake Ainslie, in Inverness county, Cape Breton island. In earlier years, a small tonnage was obtained from deposits at Five Islands, in Colchester county, Brookfield, in Hants county, and Hodson, in Pictou county; the last work on any of these properties took place over twenty years ago.

Some years ago, Barytes, Ltd., erected a mill at Scottsville, to grind and concentrate Lake Ainslie barytes. A certain tonnage was put through the mill, but operations have since been suspended. At the present time, only one property is being worked—by Brandram-Henderson, Ltd.,—the ore being shipped to Halifax, where it is ground.

Certain of the Lake Ainslie veins carry a good grade of white barytes, which is stated to run as high as 96 per cent of barium sulphate. In several cases, however, where the colour is good, the ore is low in barium sulphate, as much as 35 per cent of calcite and fluorite being shown by some samples analysed. In the case of other veins, which carry ore running 90-95 per cent of barium sulphate, the barytes is off colour, having a grey or brownish tint. This coloration cannot be removed by bleaching with sulphuric acid, and, consequently, the barytes yields only a second grade, ground product.

The Lake Ainslie barytes deposits consist of a number of more or less parallel veins cutting across a high ridge that follows the east side of the lake. The vein zone extends for a distance of about 10 miles. The maximum distance for which any one vein has been traced is stated to be 4,500 feet, and the maximum width of ore body, 18 feet. The greatest depth that has been reached in exploiting the deposits is 110 feet.

**QUEBEC.**

In Quebec province, a barytes vein on lot 7 in range X of the township of Hull, Hull county, was worked a number of years ago and yielded a small tonnage. This is the only occurrence of barytes in the Province which has yielded any production, though small deposits occur at several points in Hull, Templeton, and Buckingham townships.

**ONTARIO.**

In Ontario, narrow veins of barytes have been worked in Frontenac, Lanark, and Carleton counties. None of these deposits appear to be of important extent, and the ore in many cases contains appreciable amounts of calcite or fluorite. In several cases, the veins have evidently formed on fault planes, the vein-filling consisting of brecciated fragments of the country rock cemented by barytes and calcite.

Many years ago, barytes was mined on McKellar island, Thunder bay, Lake Superior, and about 2,000 tons is reported to have been shipped.

In the last few years, important deposits of barytes have been discovered in northern Ontario. Only one of the properties has had any important development work done upon it. This is the deposit owned by Premier-Langmuir Mines, Ltd., in Langmuir township, Timiskaming. The vein on this property has a maximum width of 6 feet, and consists of massive barytes having a coarsely crystalline, spathic character. The barytes is pure white, and analyses of the milled product, made in the ore dressing laboratory of the Mines Branch, showed 91 per cent barium sulphite.



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The only cleaning that this material had undergone consisted of a preliminary jigging after it had passed the crusher, in order to remove admixed country rock; slabs or wedges of which occur in the vein. The chief impurities in the ore consist of calcite (6 per cent) and quartz (2 per cent). Pyrite, chalcopyrite, zinc blende, and native silver also occur in very small amounts. The vein can be traced for over 200 feet, the greatest width being at the point of attack, where it is 6 feet wide. A drift has been carried 150 feet into the ridge in which the vein occurs, and a 60-foot shaft has been sunk at the entrance to the drift. A mill was erected on the property a couple of years ago, and some trial shipments of ground barytes have been made. Shipment is made by scow, by way of Night Hawk lake, to Connaught station, 35 miles distant.

Barytes has also been found in Lawson, Cairo, and Yarrow townships, all in Timiskaming district, but only work of a prospecting nature has so far been done on the deposits. Transportation difficulties hamper the immediate development of all these properties.

The deposit in Lawson township lies about 15 miles west of Elk lake, one mile south of the Elk Lake-Gowganda road. The vein has an average width of 10 feet and is exposed for a distance of 50 feet, being capped at both ends of the outcrop. It is composed of coarsely crystalline white barytes and carries little in the way of visible impurities, though analyses of the material are not available at the time of writing. A very small amount of chalcopyrite occurs as specks disseminated through portions of the vein. The colour of the barytes, when freshly broken, is a good white, though the surface ore, as is to be expected, exhibits a slight brownish tinge.

The deposits in Cairo and Yarrow townships were not examined, owing to the lateness of the season and difficulties experienced in reaching them. They have been described by A. G. Burrows, in the 27th Annual Report of the Ontario Bureau of Mines, 1918, Part I, p. 237. The following particulars regarding them are taken from this source.

The occurrence in Cairo township lies on the west side of Browning lake, in the north part of the township. The barytes vein has a maximum width of 15 feet and can be traced for over 130 feet. It narrows from 15 feet at the east end of the outcrop to 2 feet at the west end. The colour of the barytes is a good white. Minor impurities in the ore comprise zinc blende, galena, specularite, and fluorite. The vein also contains some large inclusions of the country rock (syenite). Analysis of a sample taken across 8 feet of the vein showed 90.5 per cent of barium sulphate.

The deposit in Yarrow township occurs on the creek connecting Yarrow and Mistinigon lakes. There are two veins, 5 feet and 6 feet wide, respectively, separated by a band of quartzite. The length of the veins was not ascertained. According to a report by M. B. R. Gordon, mining engineer for the Ontario Barium Company, which controls the deposit, one of the veins has since been found to have a width of 12 feet and has been traced for over 400 feet. Two samples from this vein yielded, on analysis, 81 and 98 per cent of barium sulphate, respectively, the balance in the case of the first sample being silica. The second vein, whose length is believed to be at least 700 feet, is stated to have a total width of 20 feet. It contains, however, a band of chert 6 feet thick which splits the vein into two parts,  $7\frac{1}{2}$  and  $6\frac{1}{2}$  feet wide, respectively. An analysis of an average sample from this vein showed 77 per cent of barium sulphate.

In the Sudbury district, a promising barytes vein has been discovered near Tionaga, in Penhorwood township. The deposit lies close to the track of the Canadian National railway. According to a report by C. H. Hitchcock, mining engineer, of Sudbury, the ore body has a length of at least 525 feet and a maximum width of 15 feet. The barytes is of a good white colour, and carries only a minute amount of impurities—chiefly chalcopyrite—in specks disseminated through the ore. The vein contains occasional inclusions of country rock, and in places fluorite occurs along the



contact with the country. An average sample of the barytes, analysed in the laboratory of the Mines Branch, showed a content of 97.5 per cent of barium sulphate, the residue being quartz. An average of six channel samples taken at various places on the vein, is stated to have shown 95.5 per cent of barium sulphate.

Production of Barytes.

The output of barytes in Canada in 1919 was smaller than that of the preceding year (640 tons) and only one mine reported production. The following table shows the annual production, 1912-1918:—

Year.	Tons.	Value.	Year.	Tons.	Value.
1912 .. . . .	464	\$5,104	1916.... ..	1,368	\$19,393
1913.....	641	5,410	1917.....	3,490	54,027
1914.....	612	6,169	1918...	640	10,165
1915.....	550	6,875			

CELESTITE.

Celestite is known to occur at a number of localities in Canada, but only two of the occurrences possess probable economic significance. Both these are in Ontario, one on lot 2 in concession VIII of the township of Lansdowne, Leeds county, and the other on lot 7 in concession X of the township of Bagot, Renfrew county. Both the deposits have been known for a number of years, but very little work has been done upon them.

The deposit in Lansdowne consists of a vertical vein of celestite, 12 to 24 inches wide, enclosed in Grenville crystalline limestone. There is no sharp line of demarcation between the vein and the country rock, the ore body grading into the limestone. The celestite occurs as a rather loose aggregate of tabular crystals of a prevailing bluish colour, but brown and also colourless crystals are common. The narrowness of the vein and the rather friable nature of the enclosing limestone would render it difficult, in mining operations, to prevent the celestite becoming contaminated by calcite. An analysis of a representative sample of the celestite, conducted by the Dominion Sugar Company, Chatham, Ont., showed 99.4 per cent of strontium sulphate.

The occurrence in Bagot township presents unusual features both in the character of the celestite and the form of the deposit. The celestite is of a uniform pure white colour and occurs both as irregular masses and as interlacing stringers of radiating, fibrous or columnar crystals enclosed in a matrix of brownish ankerite. The deposit is enclosed in crystalline limestone and the ankerite probably represents a zonal alteration product of this rock. The deposit of celestite and ankerite has a surface width of about 45 feet at the point where it has been opened up. Masses of pink crystalline limestone occur included in the celestite-ankerite body and are generally surrounded by varying thicknesses of celestite. The deposit dips at an angle of about 45° S. and is capped by crystalline limestone. The celestite occurs in largest amount in the hanging wall zone. The greatest width of individual stringers is about 18 inches. According to information supplied by the present operator, a 60-foot vertical drill hole put down just south of the hanging wall met the ore body at a depth of 40 feet, and 20 feet of vein material, consisting of alternating bands of celestite and pink limestone, was then passed through. The bands of celestite ranged up to 2½ feet in thickness. At this point the 45-foot ore body is estimated to carry about 40 per cent of celestite. The deposit is stated to have been traced along the strike for over 2,000 feet.



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A steam plant has recently been installed on the property and a grinding mill is being erected. It is intended to produce a finely ground celestite that may find utilization in industries at present using barytes, such as the paint and rubber trades. An analysis of the celestite, made in the laboratory of the Geological Survey, showed 85 per cent of strontium sulphate and 14 per cent of barium sulphate.

**STRONTIANITE.**

While strontianite has been recorded from three localities in Canada, none of the occurrences possess probable economic importance. The most extensive of the three deposits is that on lot 31 in concession A, township of Nepean, Carleton county, Ontario, but the occurrence is of mineralogical interest only. The outcrop occurs below high water mark on the shore of the Ottawa river and can only be examined at low water. The occurrence was not examined by the writer, but in Vol. VI of the Geological Survey, page 22R, it is stated to consist of two narrow veins, about 6 inches wide, traversing Chazy limestone. Vein-pieces, collected by A. T. McKinnon, of the Geological Survey, and examined by the writer, consisted largely of calcite and brecciated fragments of the limestone. Occurring irregularly in this material, and occasionally extending almost the entire width of the vein, are aggregates of radiating, fibrous strontianite crystals. The strontianite probably does not form more than 20 per cent of the vein filling. The material is of a pale, yellowish-green colour, grading into white. Associated with it is a small amount of pyrite.

An analysis of carefully selected material, made in the laboratory of the Geological Survey, showed 93.4 per cent of strontium carbonate, the residue being calcium carbonate.



## FUELS AND FUEL TESTING DIVISION.

## I.

## WORK AT THE FUEL TESTING STATION, ETC.

B. F. HAANEL, *Chief of Division.*

During the year 1919, the staff of the Fuels and Fuel Testing Division was very seriously reduced, through the resignations of Messrs. R. E. Gilmore and T. W. Hardy. Mr. Gilmore was engaged for the carrying out of special research work in connexion with the carbonization of fuels and Mr. Hardy for special work in connexion with gas analyses. These resignations, together with the leave of absence granted to Mr. Edgar Stanfield, chief engineering chemist, to take charge of the chemical work of the Lignite Utilization Board, very materially handicapped the work which it was planned to carry out during this year.

The money voted in the estimates for 1919-20, for this division, provided for important research work in connexion with fuels, namely, an investigation concerning the utilization of fuels for the production of power and general industrial purposes in Canada, with a view to ascertaining whether it is possible to substitute, in certain cases, hydro-electric power for power derived from fuel; and whether it will be possible to economize in the use of fuels by erecting central power plants and heating plants at strategic points. It was also planned to begin research work on the oil shales of Canada of a character similar to that which has been conducted on certain of the western lignites. The difficulty experienced in obtaining the necessary additional laboratory assistance, together with the above resignations, made it impossible to carry out certain of the investigations planned; although in the case of the oil shales, a very good start was made. Other resignations which are likely to take place in the very near future will affect most seriously not only the chemical staff, but also the engineering staff of this division, if the vacancies are not filled at the earliest possible moment.

The writer, in addition to the regular duties of laying out and directing the work of this division, has had a large amount of work to perform for the Peat Committee, of which he is secretary; and for the Dominion Power Board. The secretarial work of the Peat Committee is performed entirely by the writer.

The regular work of the Division of Fuels and Fuel Testing entailed the examination and analysis of samples of mine air received from the principal producing coal mines of the Dominion; chemical analyses and physical examination of oils for the different departments of the Canadian Government; together with general analysis and the determination of heating values of fuels received from outside sources, and of those required in connexion with investigations conducted in the Mines Branch generally.

The machine shop, which is under the control of this division, completed, and had under way, a very large amount of work in connexion with the construction of new apparatus, repairs to existing machines and apparatus, and the erection of apparatus in the various laboratories of the Mines Branch.

The laboratory for the special investigation of oils obtained by the distillation of coals, lignites, and oil shales, in retorts especially designed and constructed for this purpose, is now completed; but owing to inadequate staff it is impossible to conduct investigations for which the laboratory was equipped.



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The research work which has been under way concerning the carbonization of lignites, with a view to determining their proper treatment for briquetting, and the quantity and value of the oils recovered in their carbonization, is now nearing completion.

Mr. John Blizzard, technical engineer, was engaged in investigating powdered fuel plants of the United States and Canada, with a view to collecting data and information for the preparation of the report which it is hoped to have ready for the press early in the following year.

Mr. E. S. Malloch was engaged during part of the summer on an investigation concerning the feasibility of erecting a central power plant in the vicinity of Estevan, for the generation and distribution of electric energy from that point to Moosejaw, Regina, and intervening points along the proposed transmission line. The Mines Branch was asked to make a report on this proposed scheme for the Dominion Power Board, which board, in turn, had been asked by the Saskatchewan Government for their opinion regarding the feasibility of such a scheme. The report bearing on this subject was prepared by the writer for the Dominion Power Board.

In addition to field work performed by Mr. Malloch he had charge of the calibration of electro-thermo couples.

Since many inquiries have come to this office concerning the activities of the Peat Committee, the report of that committee for the year ending December 31, 1919, is included for general information.

The summary report of Mr. Edgar Stansfield, and of Mr. A. W. Mantle, will show in detail the work carried out under their immediate direction. The memorandum regarding the southern Saskatchewan Power Scheme, which was submitted to the Dominion Power Board, follows as an appendix.

## II.

## CHEMICAL LABORATORIES OF THE FUEL TESTING STATION.

EDGAR STANSFIELD, *Chief Engineering Chemist.*

The work of these laboratories was carried out under difficulty during the year. No steps have yet been taken to remedy the unsatisfactory laboratory accommodation referred to in previous reports; and the personnel was insufficient for the work in hand. The writer's time was mainly occupied by his duties with the Lignite Utilization Board; T. W. Hardy and R. E. Gilmore left at the end of June and October, respectively, to take more lucrative positions with commercial firms; and although two special positions were advertised for research chemists to work on oil shale, only one of these was filled, A. A. Swinnerton commencing work on May 18. There were thus three vacant positions on the staff at the end of the year.

R. E. Gilmore was engaged, until he left, on the continuation of his previous researches on lignite; J. H. H. Nicolls was in charge of work on coal and other solid fuels; T. W. Hardy, until he left, was in charge of gas analyses; R. C. Cantelo was in charge of oil analyses; and J. Moran in charge of mine air analyses. A. A. Swinnerton worked on gas analyses and on an investigation of oil shales.

The equipment has been increased by the purchase of the following special apparatus: a Redwood viscosimeter, admiralty pattern, for fuel oil; a wall pyrometer; a pulp balance; and a gas generator. In addition, a number of furnaces and retorts



were constructed on the premises; also several new mercury winches, with quick and slow motion, for gas analysis; a ball and ring melting point apparatus; and many new parts for existing apparatus.

The number of samples submitted for examination during the year from outside sources showed a marked drop from previous years. This allowed more progress to be made with the investigations mentioned below than would otherwise have been possible with the depleted staff. The samples received include: 291 mine air; 79 oil shale; 76 coal; 15 oil; 2 peat; and 22 miscellaneous samples. Of the above samples 291 were analysed in connexion with coal and other mine inspection by the Provincial Governments; 84 for the Geological Survey; 18 for the Department of the Interior; 15 in connexion with the regular work of the Fuel Testing Station; 9 for other divisions of the Mines Branch; 7 for the Department of Militia and Defence; 4 for the Department of Marine and Fisheries; 4 for the Board of Railway Commissioners; 2 for the Department of Public Works; 1 for the Department of Naval Service; 1 for the Lignite Utilization Board; 1 for a Provincial Government Department; 1 "official" coal mine sample from Alberta; and 47 for outside parties. No count is made of the very large number of samples tested in connexion with the special investigations in progress in the laboratories. Two hundred and forty-eight of the mine air samples came from British Columbia, 36 from Alberta, and 7 from Nova Scotia; the samples coming from 55 mines operated by 38 different operators.

A considerable advance was made during the year with the investigation on lignite which has been in active progress since early in 1917. This work was carried out during 1919, in close co-operation with the Lignite Utilization Board of Canada. The Board supplemented the accommodation and equipment available: erecting a semi-commercial carbonizer, and building and equipping a small briquetting plant.

The semi-commercial carbonizer referred to above, was a logical development from the information gained in the investigations on lignite carbonization during the two preceding years. The working drawings were prepared by R. de L. French, the engineer to the board. Experience gained in the operation of this carbonizer during the summer and autumn led to repeated modification and improvement, and the final pattern worked so satisfactorily that it has been taken as the basis for the design of the carbonizers to be erected for the plant of the Board near Bienfait, Sask., in 1920.

Good progress has also been made with work on the briquetting of carbonized lignite, first, with a small hydraulic press, and later with a commercial roll press. Many binders have been experimented with, both singly and in combinations.

Some further progress has been made with the laboratory scale investigation on carbonization, and results supplementary to those published in the 1918 report are included in an appendix herewith. This work, however, was suspended for the greater part of the year in favour of the semi-commercial experiments.

R. C. Cantelo completed the investigation commenced at the end of 1918 on samples of wash oils, before and after their use for the extraction of gasoline, in connexion with an investigation on the gasoline content of Canadian natural gases by D. B. Dowling of the Geological Survey; he also carried out some tests on the spontaneous ignition of gasoline.

Another investigation carried out by R. C. Cantelo was with regard to the so-called "Colloidal Fuel." He investigated the value of a number of colloid stabilizers, and showed that carbonized lignite could be employed to make colloidal fuel.

An investigation of the value of a number of Alberta coals for smithy purposes was carried out by J. H. H. Nicolls. It was found that certain coals from the Crowsnest Pass and Mountain Park areas compared favourably with commercial samples of imported blacksmith coals.

A commencement was made with an investigation of oil shale. This was planned to include two main divisions of work; first, a systematic study of the retorting of



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oil shales, in order to obtain the accurate data essential for the scientific design and control of a commercial retorting plant; second, a complete examination of samples from all the known deposits of the Dominion. It was proposed to employ two chemists continuously on this work, with assistance as required in their special lines from three members of the permanent staff. For reasons already indicated, A. A. Swinnerton has worked alone, and progress has been correspondingly slow. A partial examination of 79 samples, principally from New Brunswick, has been made; and progress can be reported on the determination of the best method for the retorting of samples.

The following results were obtained with a sample of shale from Albert mines, New Brunswick, collected by W. J. Wright of the Geological Survey. The apparatus and methods employed are essentially those described on pages 99-101 of the Summary Report for 1918. Instead of the tubular retort shown a retort of + section was employed with a charge of 3,500 grams; also the steam-jacketed condenser D was omitted from the condensing train. The following tables have been compiled from single experiments only, and are subject to revision.

TABLE I.  
Oil Shale Distillation, Summary of Results.

Test.	Temperature.	Crude Oil.	Gas.	Residue.	Unac- counted for.
Series I-Rapid heating.	Degrees C	%	%	%	%
1	350	1.7	neg.	98.0	0.3
2	400	8.1	neg.	89.6	2.3
3	410-450	12.3	1.9	84.4	1.4
4	460-500	11.0	3.0	82.6	3.4
5	450-510	11.7	2.2	83.6	2.5
6	550	12.0	4.1	78.0	5.9
Series II-Slow heating.					
7	350-550	13.4	3.5	82.8	0.3
8 with steam	350-550	12.3	3.3	83.4	1.0
9 vacuum	350-500	13.8	3.1*	81.1	2.0

\*Includes some air which leaked in.

TABLE II.  
Oil Shale Distillation—Oil Yield.

Test	Temperature.	Crude Oil.			Dry Oil.		
		Yield, Imp. gals per 2,000 lbs.	Sp. Grav.	Water by weight.	Yield, Imp. gals. per 2,000 lbs.	Cal. Val. cals. per gram.	Distilling below 180 C. by weight.
Series I-Rapid heating.	Degrees C.			%			%
1	350	4.0	0.876	40.0	2.6	10,000	-
2	400	19.9	0.822	1.6	19.6	10,200	-
3	410-450	28.6	0.861	4.7	27.4	10,250	11.0
4	460-500	25.0	0.881	1.5	24.7	10,310	8.5
5	450-510	26.7	0.877	0.4	26.6	10,215	10.8
6	550	28.0	0.857	1.8	27.6	10,210	16.5
Series II.-Slowheating.							
7	350-550	31.5	0.852	7.0+	29.6-	10,500+	*
8 with steam	350-550	28.5	0.862	0.8	28.3	10,280	18.8
9 vacuum	350-500	32.0	0.888	4.8	30.7	10,750	7.3

\*Flask cracked during distillation, some water possibly left in the oil.



TABLE III.

Oil Shale Distillation—Nitrogen Distribution.

Test.	Temperature.	In residue.	Percentage of total nitrogen content,		
			In residue.	As ammo- nia in distillate.	In gas and unac- counted for.
Original shale.	Degrees C.	%	%	%	%
1	350	0.83	100	-	-
2	400	0.85	100	-	-
3	410-450	0.82	88	1	11½
4	460-500	0.72	74	1	25½
5	450-510	0.70	70	1	29
6	550	0.66	66	2	32
7 slow heating.....	350-550	0.69	65	4	31
8 with steam.....	350-550	0.63	63	1	36
9 vacuum.....	350-500	0.71	71	1	28
			70	-	-

III.

LIGNITE CARBONIZATION.

EDGAR STANSFIELD, ROSS E. GILMORE, J. H. H. NICOLLS, T. W. HARDY, and others.

The results given in the following tables and diagrams form part of, or are a continuation of, the work described in the Summary Report for 1918. The methods and apparatus employed are those already described.

Comparative tests of carbonization of Saskatchewan and Alberta lignites, described on p. 94 *ibid*, and illustrated in Diagrams III and VI of the same report, have been continued. Diagrams I and II, herewith, show results obtained with lignite from the Great West Coal Co.'s Black Diamond mine, Clover Bar, Alberta; and from the Tofield Coal Co., Tofield, Alberta. Table I shows, in tabular form for comparison, some of the results obtained with the two Saskatchewan and four Alberta lignites tested in this series.

Table II is an enlargement, with some minor changes, of Table XI in the above-mentioned report. The full analysis of the gas produced by rapid heating of moist lignite to different temperatures is given in this table, also certain combustion data of value in calculations for furnace and flue design.

Table XII of the 1918 report gives results on carbonization of different lignites from the Estevan area, computed to a basis of coals containing 33 per cent water and 7 per cent ash. Tables III-V below give some of the original data from which the former table was computed. Table III gives analyses of the charge and residue in some of the tests. It is interesting to note that the determined volatile matter in the residue is, with one exception, lower than would be expected from the analysis of the charge and the loss in weight on carbonization; the ash is in every case lower than would be expected, and the fixed carbon is consequently higher. The discrepancy in volatile matter may to a slight extent be due to decomposition of volatile matter in the retort with the production of fixed carbon. It is probable, however, that both this



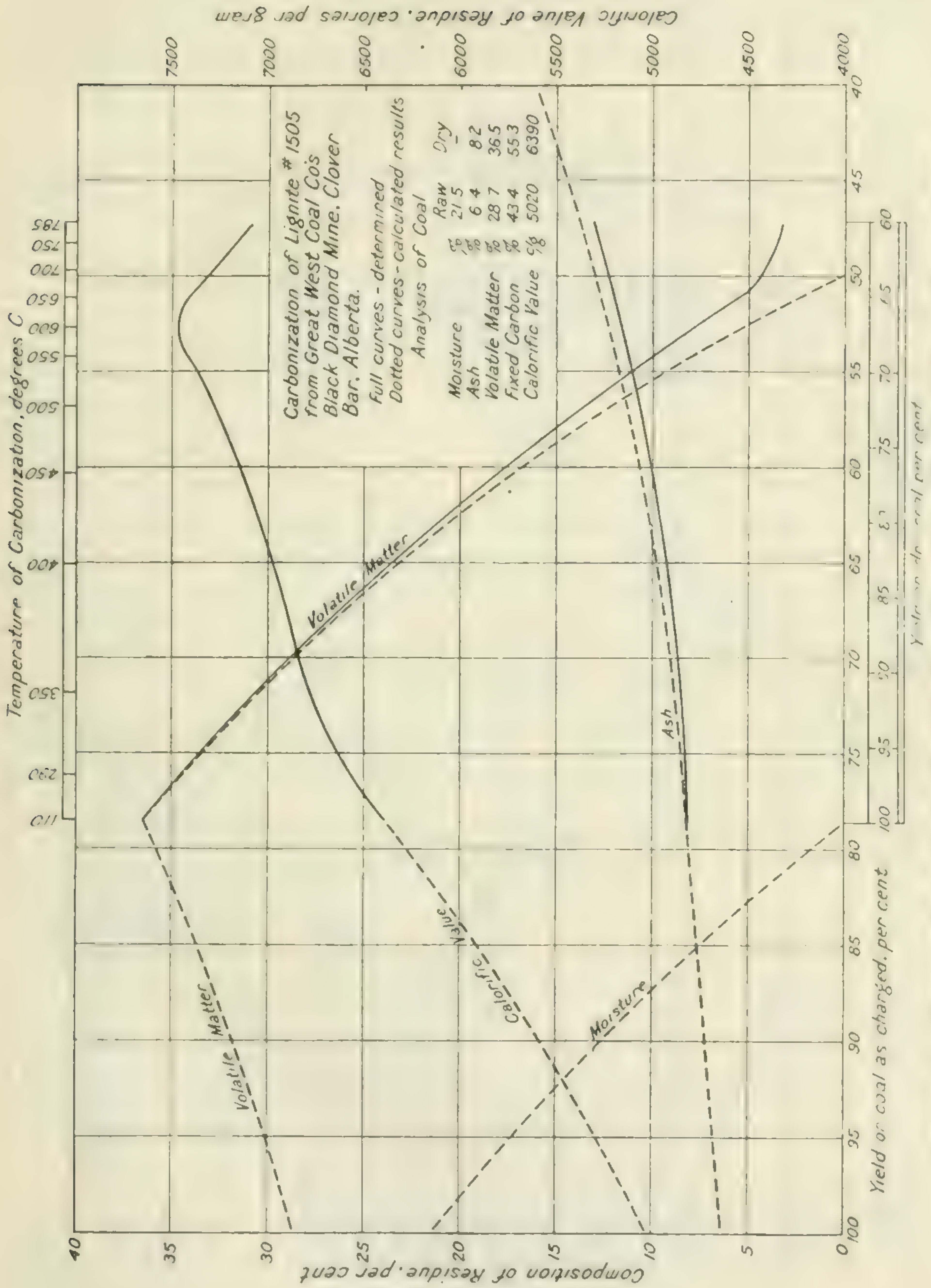


Diagram I. Carbonization of lignite No. 1505 from Great West Coal Co's Black Diamond Mine



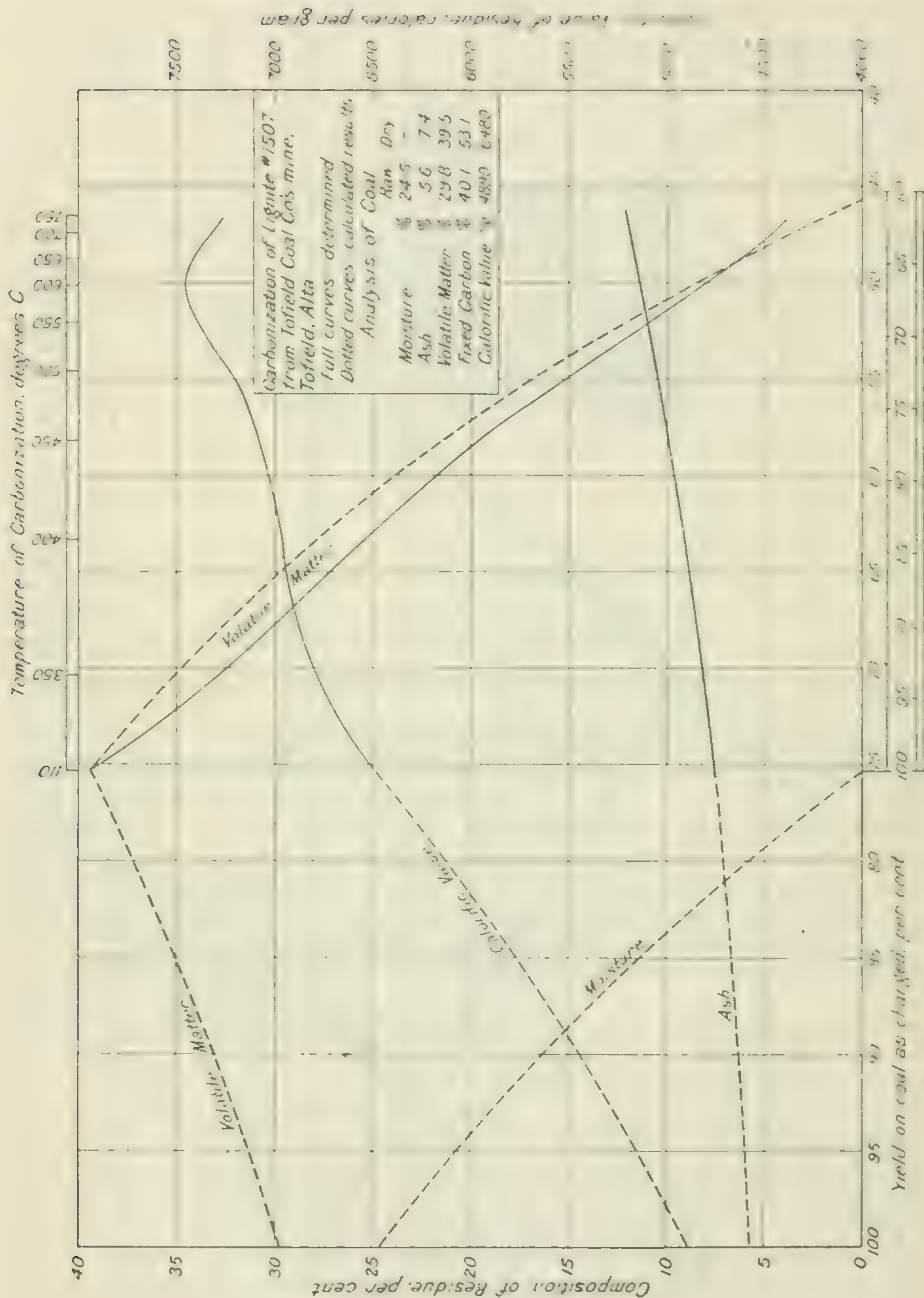


Diagram II. Carbonization of Lignite No. 1507 from Tofield Coal Co's mine.



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difference and the ash difference are in some way due to factors which are inevitably involved in the standard methods of "proximate analysis," rather than to loss of volatile matter or ash. The discrepancies here shown are typical both in sign and amount of those found in nearly all similar experiments on lignite in these laboratories. Table IV gives distillation results on the tars obtained from three of the lignites tested. Table V gives yields, analyses, and combustion data for the gases obtained in these tests.

TABLE I.

Comparison of Results of Carbonization of Saskatchewan and Alberta Lignites.

Source of Lignite.	Saskatchewan.		Alberta.			
	Saskatchewan Coal, Brick and Power Co., Shand.	Western Dominion Collieries, Taylorton.	Halbert's mine, Trochu.	Cardiff Collieries, Cardiff.	Black Diamond mine, Great West Coal Co., Clover Bar.	Tofield Coal Co., Tofield.
Raw lignite—						
Moisture..... %	31.8	31.3	17.3	23.6	21.5	24.5
Ash..... %	5.2	8.0	8.4	7.6	6.4	5.6
Volatile matter... %	28.9	28.0	27.2	29.6	28.7	29.8
Fixed carbon..... %	34.1	32.7	47.1	39.2	43.4	40.1
Calorific value—						
Cals. per gram	4260	4160	5320	4660	5020	4890
B.Th.U. per lb . . . .	7670	7490	9570	8390	9040	8810
Dry lignite—						
Ash..... %	7.6	11.6	10.1	10.0	8.2	7.4
Volatile matter... %	42.3	40.8	33.0	38.7	36.5	39.5
Fixed carbon..... %	50.1	47.6	56.9	51.3	55.3	53.1
Calorific value—						
Cals. per gram	6260	6050	6430	6100	6390	6480
B.Th.U. per lb .	11270	10890	11580	10980	11510	11670
Carbonized lignite at temp. of max. C.V.—						
Ash..... %	11.6	16.7	13.8	14.5	11.6	11.3
Volatile matter... %	—	9.2	7.8	7.5	7.9	7.9
Fixed carbon..... %	—	74.1	78.4	78.0	80.5	80.8
Calorific value						
Cals. per gram.....	7530	7030	7170	7130	7470	7460
B.Th.U. per lb.....	13560	12650	12900	12840	13450	13430
Gain in Calorific Value on Carbonization, at specific Temperatures. Dry coal basis.						
350° C.	10.5	7.8	3.7	7.6	6.4	4.5
400° C.	13.6	9.9	4.7	9.8	9.5	7.4
450° C.	16.3	10.8	6.5	11.6	11.9	9.3
500° C.	18.8	13.7	8.6	14.4	13.8	11.6
550° C.	20.3	16.2	10.0	16.1	16.1	14.0
575° C.	20.2	16.0	10.9	16.6	16.7	14.7
600° C.	20.1	15.5	11.4	16.9	16.9	15.0
625° C.	19.8	14.7	11.5	16.9	16.7	14.8
650° C.	19.3	13.6	11.4	16.7	16.2	14.5
700° C.	18.0	12.5	10.7	16.1	13.9	12.8
750° C.	17.1	11.2	9.6	14.1	12.4	12.0
800° C.	16.1	—	8.4	13.2	10.3	—
Maximum increase of C.V.—	%	%	%	%	%	%
From raw coal.....	76.8	69.0	34.8	53.0	48.8	52.4
From dry coal.....	20.3	16.0	11.5	16.9	16.9	15.0
Yield for maximum C.V.—	%	%	%	%	%	%
From raw coal	46	46	58	51	53	50
From dry coal.....	67	67	71	67	67	67







TABLE IV.

Distillation Results on Lignite Tar from Carbonization of Estevan Area Lignites  
at 575-600° C.

Source of Lignite.		Shand mine	Western Dominion mine.	Bienfait mine.
Test Nos. ....		141-2	143-4	145-6
Water in crude tar.....	%	4.1	4.2	4.4
Results on dry tar basis—				
Up to 170° C....	%	8.2	3.8	4.7
170°-200°....	%	4.5	4.9	3.8
200°-270°....	%	28.3	23.9	23.4
270°-310°....	%	19.3	20.4	20.9
Residue.....	%	36.5	45.1	45.3
Gas and loss.....	%	3.2	1.9	1.9

TABLE V.

Gas Results, Lignite Carbonization.  
Comparative Series—Estevan Area.

Source of Lignite.	Western Dominion mine, Taylorton.		Manitoba and Saskat- chewan, Taylorton.	Bienfait mine.		Shand mine.		Estevan Coal and Brick Co.	
Sample No. ....	1075	1076	1082	1077	1078	982A	1081	1079†	1080
Experiment Nos. ....	143-4	153	149-150	152	145-146	154	141-2	151	147-8
Temperature, °C. ....	575	575 +	575 +	575 +	575	575	575	575	575
Yield per 2,000 lbs. as charged, c.f. ....	3160	3420	3325	4205	4000	3310	2965	3145	3020
Dry basis c.f. ....	4775	5075	4875	5275	4935	4940	4505	4770	4640
Yield per lb. of residue, c.f. ....	3.99	3.91	3.73	4.04	3.83	3.77	3.28	3.73	3.48
Analysis of gas—									
Carbon dioxide..... %	40.6	39.5	40.0	44.2	44.7	39.5	40.0	35.2	42.7
Ethylene, etc..... %	2.6	2.5	2.5	1.8	2.0	2.4	2.3	1.9	2.3
Oxygen..... %	0.4	0.3	0.3	0.3	0.4	0.2	0.4	0.3	0.3
Carbon monoxide..... %	9.3	9.7	9.4	11.0	10.5	9.9	8.8	9.5	10.1
Methane..... %	29.1	28.6	28.0	26.7	27.4	28.3	29.2	20.4	26.7
Hydrogen..... %	15.4	17.9	18.3	15.0	12.9	18.5	16.7	10.9	15.8
Nitrogen..... %	2.5	1.5	1.5	1.0	2.1	1.2	2.6	1.8	2.1
Calorific value (calculated)—									
Gross, B. Th. U. per c.f.	410	415	410	380	380	415	410	380	385
Net B. Th. U. per c.f. ....	370	375	370	340	345	370	370	270	350
Density (calculated) . . .	0.94	0.91	0.91	0.97	1.00	0.91	0.92	1.00	1.00
Combustion data—									
Air required..... vols	3.73	3.74	3.60	3.42	3.45	3.72	3.72	2.70	3.49
Flue gas*..... vols	4.01	4.61	4.58	4.30	4.34	4.59	4.59	4.62	4.36
Water in flue gas..... %	17.1	17.4	17.8	16.7	17.0	17.4	17.4	15.9	16.9
Dry flue gas..... vols.	3.82	3.81	3.76	3.58	3.61	3.79	3.79	3.04	3.62
CO <sub>2</sub> in flue gas..... %	22.0	21.7	21.9	23.9	24.0	21.7	21.8	29.2	23.2

NOTE.—\*Water assumed to be present as a gas. The dry flue gas is with water condensed.

†Outcrop sample.

Gas yields and calorific values are in terms of cubic feet of moist gas measured at 60° F. and under a pressure of 30" of mercury. Gas densities and combustion data are for dry gas and dry air, unless otherwise stated.

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*Rapid Carbonization of Lignite.*—Diagrams I and III-VI in the 1918 report, and diagrams I and II above, show that the maximum calorific value of the residue is obtained by carbonization at a temperature of about 600° C. It is clear from the shape of these curves that if lignite is heated in a retort under the conditions usually met in commercial operations, with the layers near the wall very distinctly hotter than those in the centre of the charge, no regulation of the average temperature of the mass will give a residue with the maximum attainable calorific value. The amount the calorific value of the residue falls below the optimum will increase with the thickness of the charge and with the temperature gradient from the walls to the centre.

Some preliminary experiments were carried out to test the possibility of obtaining the equivalent of carbonization at say 600° C. by short exposure in a thin layer to a distinctly higher temperature. The method employed was as follows: samples of dried Shand lignite, crushed to pass a 10-mesh screen, were carbonized for a definite number of minutes in a metal box in a muffle furnace electrically heated to temperatures of 750°-800° C. The boxes were 6 inches by 3 inches by 1 inch inside, or No. 18 gauge sheet iron, with loosely fitting rim lids of the same metal. When making a test the muffle was brought up to heat, and the lid of the box was also heated. A charge to half fill, or to quite fill the box was weighed out and placed in the cold box; the heated cover was then put on, the box immediately placed on the floor of the muffle, and the muffle door closed. At the expiration of the desired time the box with its contents was removed from the muffle, cooled as rapidly as possible and the residue weighed and analysed.

No great accuracy is claimed for the results, which are shown graphically in diagram III. It is obvious that the number of experiments should have been considerably increased to render the curves reliable. They do, however, show that the results of such rapid carbonization follow the lines which theory indicates, but the advantage to be gained by further experiments was not thought to be commensurate with the work involved.

Table VI compares the results obtained by complete carbonization of the same lignite at 590°C. and 600°C. with the optimum results for ½" and 1" layers carbonized in a muffle at 800°C. as taken from the rounded curves of diagram III.

TABLE VI.

Method of carbonization.		In lead bath.		In muffle.	
		at 590°C.	at 600°C.	at 800°C.	at 800°C.
Thickness of layer.....		—	—	½"	1"
Time of carbonization.....		Until completed.	Until completed.	5 minutes.	9 minutes.
Yield .....	%	67.5	67.1	69.2	67.0
Ash .....	%	18.9	18.9	18.7	19.4
Volatile matter.....	%	8.7	8.4	9.0	7.9
Fixed carbon.....	%	72.4	72.7	72.3	72.7
Calorific value, calories per gram		6760	6750	6690	6590



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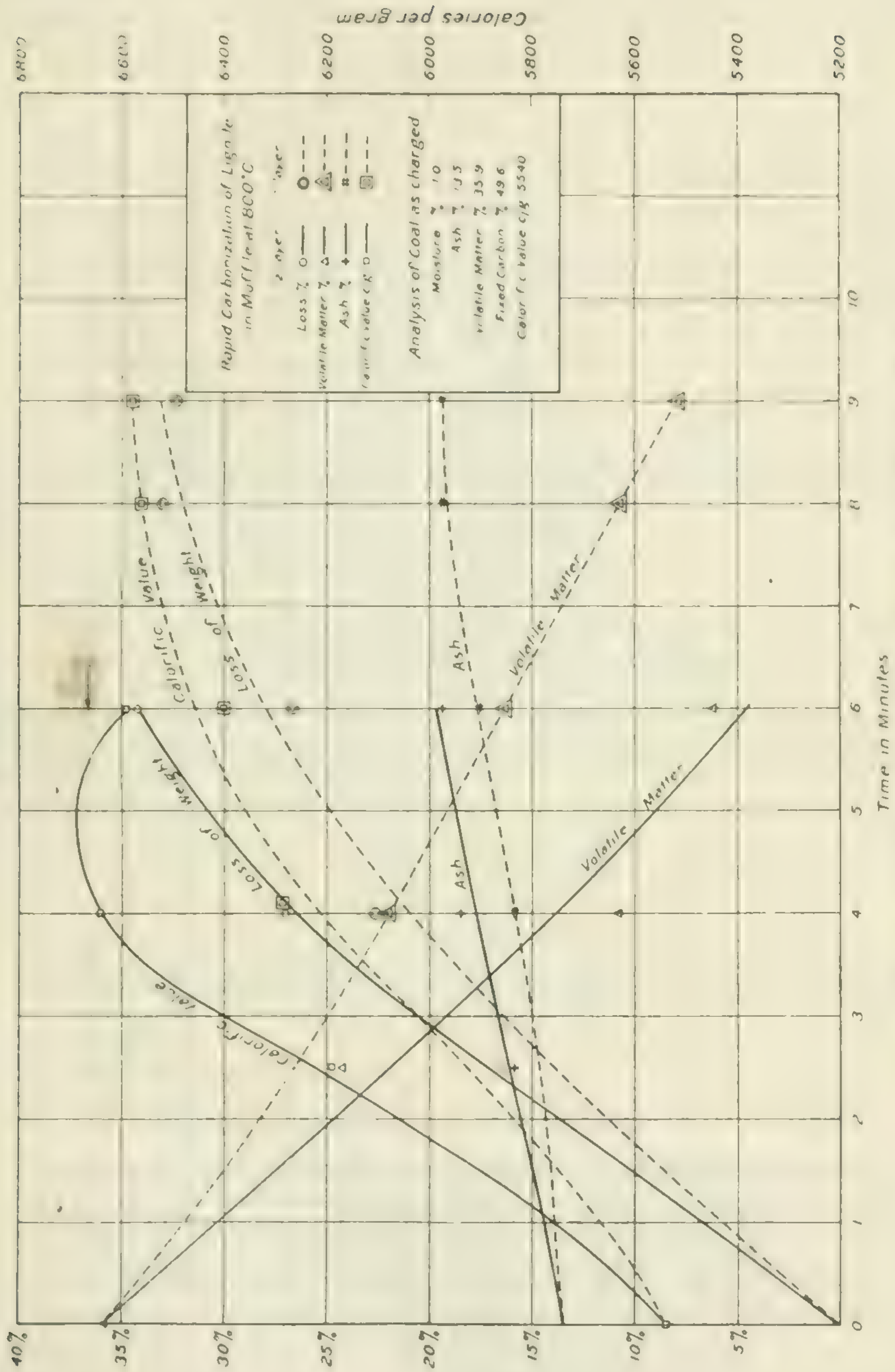


FIGURE III Rapid carbonization of lignite in muffle at 800°C



*Water in Lignite.*—Diagram IV shows the results of a preliminary experiment carried out to determine the relation between the quantity and the vapour pressure of the water in a sample of lignite. A slow current of dry air was aspirated through a bottle containing crushed and screened coal from Pembina, Alta. The temperature

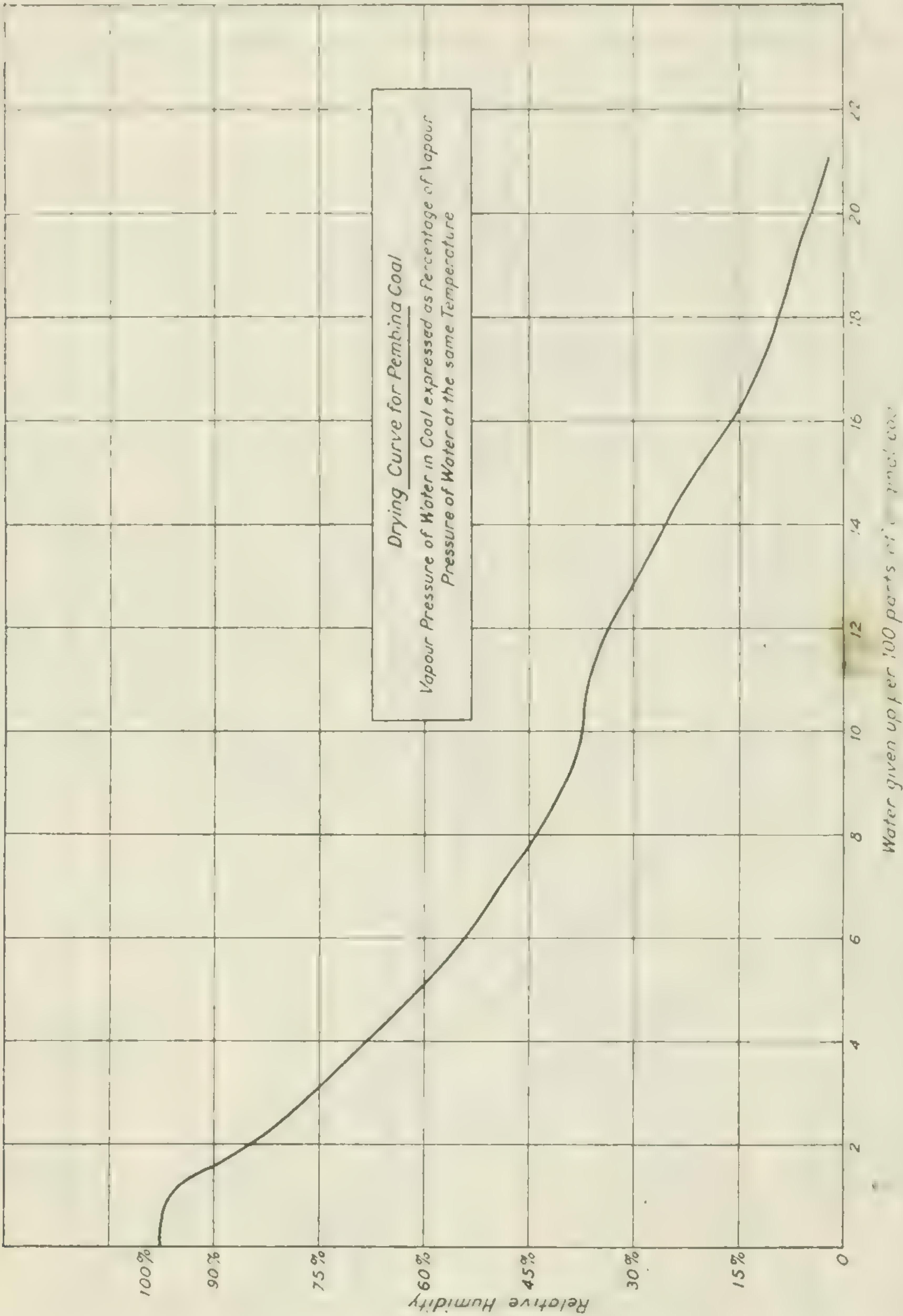


Diagram IV. Drying curve for Pembina coal.

of the coal, the volume of air aspirated, and the weight of water removed, were recorded at frequent intervals. No attempt was made to keep the coal at a uniform temperature, but in order to minimize the effect of the change of temperature the vapour pressure of the moisture in the coal was expressed as a percentage of the



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vapour pressure of water at the same temperature. This relative humidity is shown plotted against the weight of water given up per 100 parts of the original coal. It was found that the relative humidity tends to increase with increase of temperature. The slow drying of the coal took four years, over 2,000 cubic feet of air being aspirated through the kilogram of coal taken.

The results obtained are complicated by slow oxidation of the coal, as well as by temperature changes; the results, however, indicate that the vapour pressure of water in lignite steadily decreases from 100 per cent relative humidity as the lignite dries.

Diagram V shows the loss and gain of moisture by Estevan area (Souris) lignite exposed moist and dry in air of 60 per cent humidity. Samples of about 4 grams in weight of raw and of dried lignites, crushed to pass a 10-mesh screen, were exposed in watch glasses of 2 inches diameter in a desiccator containing a solution of calcium chloride of 1.30 specific gravity. The watch glasses and contents were weighed from time to time, and the respective losses and gains recorded. The above solution of calcium chloride at ordinary temperatures has a vapour pressure approximately 60 per cent of that of pure water at the same temperature.

The curves indicate that equilibrium would be reached with from 14 to 16 per cent of moisture in the different samples. Varying the humidity of the air would give a different equilibrium point, as illustrated, though on a higher grade of lignite, in diagram IV. Varying the size of particles, quantity exposed, thickness of layer, circulation of air, etc., would all cause a variation in the rate of loss or gain of moisture, but should not materially affect the final equilibrium.

The samples tested were as follows:—

No. 1425—Woolloomooloo mine, Estevan.

No. 1441—Saskatchewan Coal Co's. mine, Roche Percée.

No. 1444—Interprovincial Coal Co's. mine, Roche Percée.

Carbonization tests have been carried out under pressure, in an atmosphere of steam, and at temperatures higher than previously reported, but the results are not yet ready for publication. The same is true with regard to the tests with the semi-commercial carbonizer previously referred to.

## IV.

## REPORT OF MECHANICAL WORK AT FUEL-TESTING STATION.

The Chief Engineer,  
Fuels and Fuel Testing Division,  
Mines Branch,  
Sussex Street, Ottawa.

DEAR SIR,—I submit herewith Summary Report for the fiscal year ending March 31, 1920, of the Mechanical Division of the Mines Branch, Department of Mines.

Experimental machines and apparatus not completed at the close of the previous fiscal year were finished and installed during the past fiscal year.

The mechanical staff was kept busy on work in connexion with the activities of the Lignite Utilization Board, and on the usual routine work necessary for the maintenance of the department's apparatus and mechanical equipment.

Respectfully submitted,

(Signed) A. W. MANTLE,

*Mechanical Superintendent.*



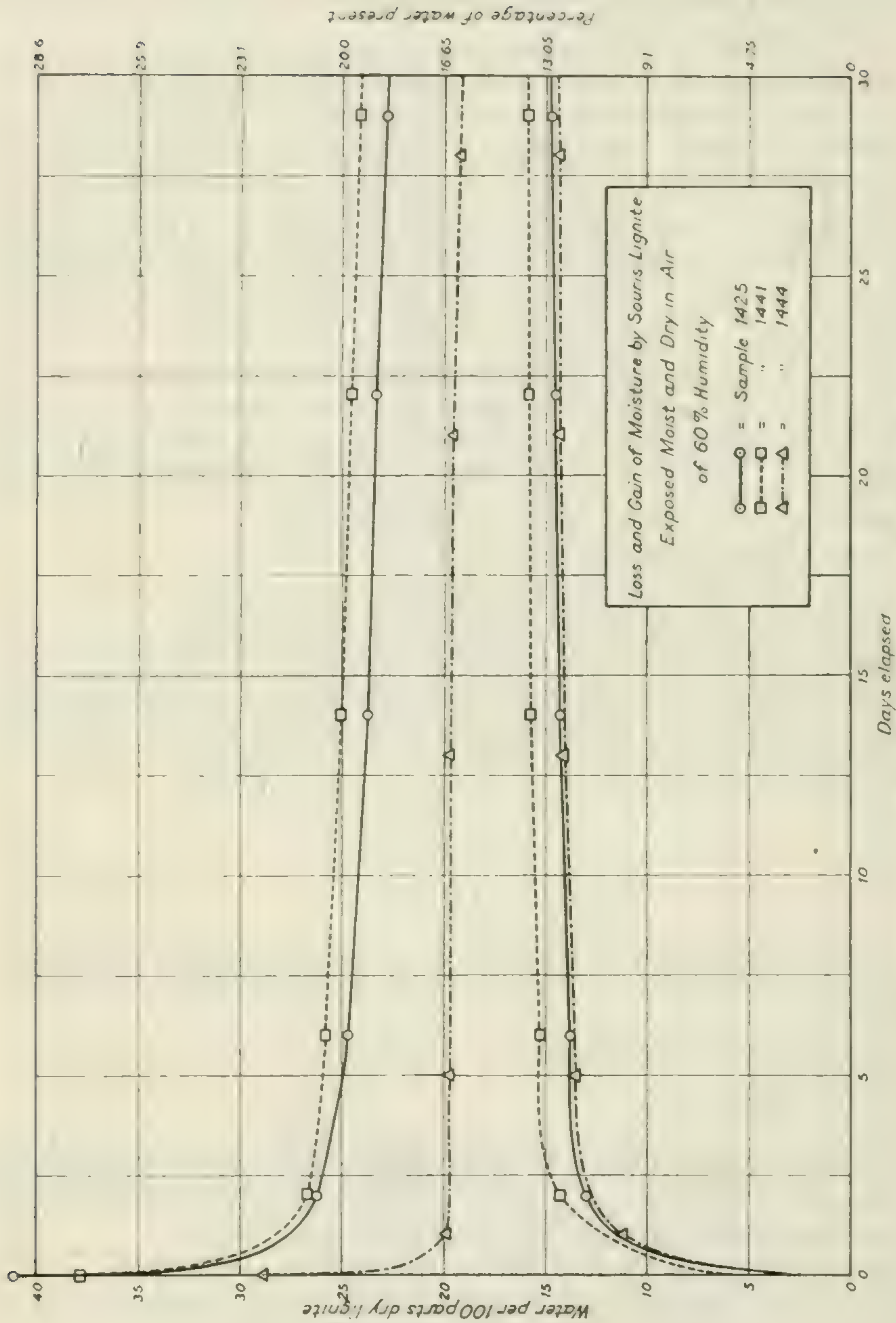


Diagram V. Loss and gain of moisture by Souris lignite.



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SUMMARY COST STATEMENT OF LABOUR COMPLETED, AND  
MATERIAL USED, DURING THE FISCAL YEAR ENDING  
MARCH 31, 1920.

Division.	Time.	Material.
Ore Dressing Division.. . . . .	\$2,379 66	\$ 466 70
Fuel Testing Division.. . . . .	1,112 77	164 88
Chemistry Division.. . . . .	679 15	126 51
General Mines Branch.. . . . .	542 32	127 82
Non-metals Division.. . . . .	162 09	11 75
Ceramic Division.. . . . .	70 44	45 84
Structural Materials Division.. . . . .	140 31	9 50
Lignite Board . . . . .	575 36	72 39
Totals.. . . . .	\$6,662 10	\$1,025 39

## V.

### REPORT OF THE PEAT COMMITTEE FOR THE YEAR ENDING DECEMBER 31, 1919.

By B. F. HAANEL, *Secretary to the Committee.*

#### Introductory.

When the Peat Committee was first appointed in the early spring of 1918, it was confidently expected that a mechanical demonstration of the two different types of peat machines, which the committee had given its engineer instructions to design, would be completed during the working season of that year. A short time, however, after the contract for the construction of these machines had been awarded, it became apparent that in all probability the machines would not be completed in time to try them out before winter set in. The reasons for the delays in the shop—which prevented their delivery at the time specified—were fully set forth in the first report of the Peat Committee for the year ending December 31, 1918.

The season of 1919 was consequently begun with one plant (No. 2), which was of an altogether new and novel design, partly erected on the grading of the old Alfred railway siding; and the other plant (No. 1), loaded on cars held on the main line of the C.P.R.

#### Mechanical Try-out of, and Alterations to the Two Types of Peat Machines.

During the next six months the two plants were completely assembled, taken to their working faces and put in operation in order to discover weak points which it was anticipated would develop in machines incorporating many novel features and new design which had not been tried out before. The only radical change in the design of plant No. 1 or the Anrep plant was the mounting of this machine on caterpillars, consequently little trouble was expected with it, and the committee had every reason to expect that as soon as this machine was moved to its working face, the operation of manufacturing peat fuel could be started immediately. Difficulties of a serious nature were, however, disclosed in the driving mechanism of the caterpillars when the machine was moved under its own power from the railway siding to its working face, a distance of some 2,000 feet over the bog, which at that time



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was partially covered with water. After it had been placed in position for operating, a thorough inspection of the caterpillars disclosed the seat of the trouble; and since the mechanism of the two machines is identical, arrangements were immediately made to alter the design. It is necessary here to point out that very serious trouble was also experienced with the field spreader and track layout system for transporting the pulped material to the drying field. The designs for these were obtained from Sweden, and moreover were strictly adhered to, inasmuch as this method for spreading the pulped peat is an integral part of the Anrep plant. In making the necessary alterations to overcome this trouble several weeks were consumed, and it was therefore not until some time in June that an attempt could be made to manufacture peat fuel at anything approximating a normal rate.

Inasmuch as a machine of this type had been employed before, and the Peat Committee were desirous of obtaining as large an output of manufactured peat as possible during the working season, the larger part of the time of the engineer and his staff was concentrated on this plant.

Plant No. 2 was an entirely new departure in peat machinery design, hence it was not expected that it could be successfully operated before a great deal of experimentation entailing many alterations had been conducted; but the difficulties which were discovered were not of a serious character; and if the machine had been placed in a more favourable position on the bog, it could have been got into condition for manufacturing peat fuel before the end of the season. As stated previously, the driving mechanism for the caterpillars on both machines was strengthened, and later on in the season a differential drive was installed on both. With these alterations the caterpillars worked perfectly.

Plant No. 1 (Anrep system) was put in operation on the old working face situated on that part of the bog which has been well drained for some years. Moreover, this portion of the bog was in excellent condition owing to the manufacturing operations which had been conducted during past years. No difficulty, therefore, was encountered from holes, soft spots, or the sinking of the machine in the bog, which was the case with plant No. 2 (Moore system), which had to be operated on an undrained portion of the bog, over a distance about a mile parallel to the Canadian Pacific Railway tracks. This portion of the bog was not only undrained, but had been previously burned, leaving soft spots and holes, some of which it was necessary to fill as the work progressed. Plant No. 1 had also a well prepared working face and could therefore begin manufacturing operations at once, while in the case of plant No. 2 it was first necessary to construct a working face before peat fuel could be manufactured. This plant was therefore employed, during the time it operated, excavating a working face.

A certain amount of peat fuel was manufactured by plant No. 2 during the time it was employed on this work, but the machine was not operated for this purpose, but for observing difficulties and in remedying the same. The principal feature in the design of this machine is the arrangement for replacing the ordinary track system, cars, cableways, etc., which are absolutely necessary for transporting the pulped peat, and for spreading it on the drying field when the Anrep system is employed. With the Moore system this is effected by means of a bridge about 150 feet long attached at right angles to the peat machine. This bridge is equipped with a belt conveyer and a spreader which is attached to the bridge and travels in a direction parallel to that of the peat machine. Inasmuch as this system for spreading peat has not previously been tried in connexion with any peat machine, it was naturally found upon trial that certain alterations to the machine would have to be made before it could be operated satisfactorily. For example, it was found on trial that the bridgework was hung so low that sufficient clearance between the bottom of the bridge and the top of the bog could not be obtained. This, with a few minor alterations to the spreader, constituted



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the principal changes made. If, however, the machine had been tried on a more solid portion of the bog the bridgework might have worked satisfactorily without any alterations. Notwithstanding the difficulties under which this plant was operated, about 800 tons of peat fuel were manufactured during the period of its mechanical try-out.

Plant No. 1 manufactured over 2,000 tons of peat fuel, and its capacity per day increased steadily up to the time operations were discontinued. With the information which the Peat Committee has at hand for this season's mechanical try-out and operations, they have every reason to expect an average output of 6 tons per hour for each machine during a normal season. This output it is expected will be exceeded with plant No. 2. Six tons per hour, however, is looked upon as a conservative, average hourly output.

Sufficient data concerning mechanical difficulties and weak points in the design of both machines were obtained to enable the Peat Committee to put the machines in first-class working order for the season of 1920.

### Boilers.

The Peat Committee encountered a great deal of difficulty in purchasing boilers for the two plants, in fact, the great demand for materials of all kinds for war work made the construction of these two peat plants not only difficult, but very costly. It was originally intended to install watertube boilers for burning peat fuel, since such boilers, for the same capacity, are much lighter and more compact than the locomotive type of boiler; but it was found to be absolutely impossible to obtain boilers of the former type, hence the committee was forced to install coal-burning, locomotive boilers, in order to permit of the operation of the plants during this season. Attempts were made to burn peat in these boilers, but the experiment was not successful, owing mainly to the grate area and combustion chamber being too small.

Arrangements have now been made for installing water-tube boilers suitable for the burning of peat fuel, so that when the season of 1920 begins, power for operating the peat machines will be derived from this fuel.

### Construction of Office Building, Narrow Gauge Tracks, and Installation of Harvesting Equipment for the purpose of expediting the work of the Peat Committee at the Bog.

A two-story frame building was erected in a convenient position with regard to the two peat machines and the other parts of the field. The upper story of this building is used as an office for the engineer and his staff, while the lower part is used for storage, and as a repair shop. This office is connected with the main line of the Bell Telephone Company, also, with the peat machines, and other parts of the field, by means of a field telephone system. This telephone installation has been the means of saving much time.

Approximately two miles of narrow gauge tracks, with sidings and the necessary switches, were constructed and a loading trestle was erected adjacent to the Canadian Pacific Railway siding. Later on in the season it was found necessary to also erect a storage trestle.

The harvesting equipment consists of a gasoline locomotive and 16 narrow gauge trucks. Provision is now being made to obtain another train of harvesting cars. This will enable the full output of both plants, working day and night, to be handled conveniently, and without loss of time.



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Attention should be directed to the fact that this is the first time, in any of the attempts to manufacture peat fuel, that a standard harvesting and loading equipment has been installed, and that the manufacture of peat fuel can now be performed more efficiently and at less cost than ever before.

### Observations Concerning the Drying of Peat Fuel.

In all previous efforts which have been made to manufacture peat fuel in Canada, little or no attention was paid to the drying of peat on the field. This is one of the most important phases of the manufacture of peat fuel, since the quality of the fuel very largely depends on its removal from the drying field at the proper time. With a view to obtaining such information as would best assist those desirous of engaging in the manufacture of peat fuel, the Peat Committee deemed it a duty to conduct an investigation concerning problems connected with the drying of peat fuel: for example, the rate at which it dries during the summer months; the logical time for harvesting and shipping; and the proper time for beginning and terminating operations.

With the permission of the Mines Branch of the Department of Mines, the services of Mr. H. A. Leverin were obtained for conducting this investigation. Mr. Leverin spent a considerable portion of the summer months on the bog, systematically sampling the peat fuel in order to determine from time to time its moisture content; the rate of evaporation; and for the purpose of enabling him to determine other factors necessary to the making of a complete report regarding this phase of the manufacture of peat fuel. The necessary meteorological instruments were installed to enable daily observations to be made of the rainfall, humidity, barometric pressure, and temperature.

This report will be included in the final complete report of the Peat Committee, since this investigation has not yet been carried to completion.

### Operation of Plant No. 1.

Plant No. 1 was operated intermittently from June 6 until September. In June, peat was manufactured for a period of 74½ hours, during which time 32½ rows, or 357 tons of 25 per cent moisture peat fuel were laid down; in July 104 hours produced 53 rows, or 583 tons; in August 110½ hours produced 62½ rows, or 687 tons, and during the first part of September the plant operated 44 hours and produced 25½ rows, or 280 tons. From these figures it will be seen that the capacity of this plant was, in June, 4.8 tons per hour; in July, 5.6 tons per hour; in August, 6.2 tons per hour; and in September, 6.4 tons per hour.

In June it took an average of 2¼ hours to lay one row of peat; in July, 1 hour and 50 minutes; in August and September, 1 hour and 45 minutes were required to lay the same amount of material; which shows that this machine was approaching its average normal capacity per hour as the season advanced and the men became better acquainted with their work. The above figures have been calculated on the assumption that a row of peat will yield 11 tons of 25 per cent moisture peat fuel. This figure was verified as the minimum figure, from the recorded weights of peat fuel which were taken from the field during the harvesting operations. The capacity of the harvesting cars average over 3,000 pounds of fuel per car, and five rows yield about 38 cars, or 57 tons. Plant No. 1 actually excavated 437,000 cubic feet of raw material, which should yield 11 pounds of fuel per cubic foot. The total quantity of peat excavated should therefore total 2,400 tons, and this should represent the season's output, but, according to the above figures, the season's output was only 1,900 tons.



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The difference between these two quantities can only be accounted for by the peat left on the ground, the raw material washed back into the cut, and the lower yield per cubic foot from the top 6 to 12 inches of the bog. The figures given here are therefore conservative as regards the capacity of the machines during the hours they actually manufacture peat fuel.

### Operation of Plant No. 2.

During the entire season, which was spent in experimentation and alterations, 9 rows of peat fuel were laid down, the first two amounting to very little, the third at about half the capacity of the machine, and the balance at more or less full capacity. One hundred and sixty thousand cubic feet of raw peat were excavated from the working trench, which had an average depth of five feet at the end of the season. This quantity of raw material represents a production of about 800 to 900 tons, but on account of the deep moss covering the top layers of the bog, which was included in the total excavation, probably not over 600 to 700 tons were made, and this was laid down so late that only a small portion could be sufficiently dried for fuel purposes.

Number 2 drying field was practically undrained, and, hence, was very wet. Drying, therefore, did not take place as rapidly as it will in the season of 1920, when this field will have had the benefit of the drainage produced by the excavation of its working face.

Excellent fuel, however, was made with this machine, which was operated with a maximum complement of six men; and when it approached its normal capacity, produced an equivalent of between 6 and 7 tons per hour. No positive data could be obtained regarding its maximum capacity, since the working face never reached its normal condition.

This plant is now in first-class working order, and no trouble of a serious nature due to mechanical defects is expected when it begins operations again.

### Cost of Turning and Cubing Peat.

With Plant No. 1, some 170 rows of peat fuel were manufactured, and of these, 168 rows were turned by contract at \$1.80 per row, and 58 rows were cubed at the same price, the other rows, 59 to 70, were cubed at \$2 per row, and the balance—in an effort to hasten drying before the frost—was cubed before it should have been done, by day labour, during the time the men were idle while alterations were being made. The peat, up to about row 85, was harvested and the balance left in the field, rows 85 to 140 being in cubes. It may be necessary here to explain that, in manufacturing peat fuel according to the air-dried, machine process, the peat spread on the ground is allowed to dry until the peat blocks are strong enough to stand handling, they are then turned, to permit the reverse side of the block to dry. After drying has proceeded to a certain point, which is determined by experience, these peat blocks are piled up in open stacks to complete the drying.

The production cost of the fuel is indicated in the sheet showing operating costs; but while these costs are estimated only on the time during which the plants actually manufactured peat fuel, it is satisfactory to observe that of the \$3,050.77 shown, not over two-thirds, or \$2,000, can be charged to the manufacture of the 1,900 tons of fuel mentioned above. The remaining third of the time the men were idle while repairs or changes were being made, of which no detailed account was taken in the distribution of the time of the men.

With regard to the item for turning and cubing, the figure "\$504.21 straight time" produced only 770 tons of cubed peat, which would show a cost of 62 $\frac{3}{8}$  cents



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per ton for cubing by adults as straight time, but it must be borne in mind that this peat was still very wet, nearly three times its normal weight being handled, and cubing under these conditions would never have been resorted to if it had not been deemed necessary to make every effort to get as much fuel as possible dried before the frost. The actual contract basis in 1919 was \$1.80 per row for turning, and \$1.80 per row for cubing. This latter figure towards the end of the season was raised to \$2 per row. At this figure the maximum cost of turning and cubing a row, or 11 tons, amounts to 35 cents per ton. It is the opinion of the engineer in charge of operations, that it will not be necessary to cube peat fuel manufactured prior to August, and if this is borne out in practice next season it will mean a considerable saving.

*Repairs.*—The \$672.72 expended in repairs represents mainly the cost of renewing the grips on the spreader cars, and splicing the cable, which operation had to be performed many times before a new cable could be obtained. This cable was purchased according to the Swedish specifications, but proved to be too small for the grips on the cars, consequently both the grips and the cable were worn excessively. One man, and sometimes two men, had to be kept at this work continually in order to keep the plant running, but after the new cable was installed only one man was necessary to look after the cars and the cable, and even he had very little to do. It is hoped that with the new cars which will be purchased, there will be one spare car all the time. This will permit any repairs to the cars to be made by the general repair man, which will very materially reduce the expenditure mentioned above.

*Fuel.*—The item for fuel and supplies cannot be accurately distributed, since steam was kept up practically all the time on both plants, while the plants were actually manufacturing fuel for a comparatively short period. Only a portion, therefore, of the fuel cost can be charged to the manufacturing of peat fuel. The installation in 1920 of boilers on both plants suitable for the burning of peat fuel will very greatly reduce the fuel cost just cited. It is estimated that with these new boilers peat fuel will be burned at a rate of about three tons per 10 hours for each machine, or 6 tons for 10 hours for the two machines.

### Summary of Work Accomplished during the Season of 1919.

The two types of plants were assembled and moved to the respective portions of the peat bog where it was intended they should operate. Both machines were given a severe mechanical try-out, covering a period of several months. The minor defects in the design, and mechanical weaknesses which were disclosed as the test progressed, were rectified on the field, and those which were of a more serious character, and which required more attention, were performed at the close of the season.

No fundamental mistakes in the design of either plant, with the exception of the track lay-out system and spreader for plant No. 1, for which the committee was in no way responsible, were disclosed. It was found necessary to make only minor alterations, and to strengthen certain parts at the end of the season. The area of the caterpillars of both machines was increased; this will permit these machines to travel over a comparatively soft bog without causing inconvenience. A novel departure in peat machinery design, namely, the employment of caterpillars on which the machines are mounted, proved a great success, and during a season's operations when peat fuel will be manufactured continuously, a very great saving in time and money will result from their introduction.

Mistakes inherent in the spreading system of plant No. 1 will have been corrected by the time operations commence in the season of 1920.

Plant No. 2 had sufficient of a mechanical try-out to determine its weaknesses, and all these will be remedied by the beginning of the 1920 season, so that it is



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expected that both plants will be operated at full capacity during the coming season for two 10-hour shifts. If this hope is realized, production next year will be on a large scale.

Valuable experience has been gained in the harvesting of the manufactured fuel, and its loading on to cars; and a material reduction in the cost of transportation of the fuel from the field to the cars has been realized. The Peat Committee, in addition to the work conducted at the bog, have been in negotiation with the Canadian Pacific Railway with a view to obtaining a reduction in the freight rates between Alfred, Ottawa, Montreal, and other points. The freight rate on a ton of peat fuel to these points was \$1.50 from Alfred to Ottawa, and \$1.65 from Alfred to Montreal. As a result of the negotiations carried on with the Canadian Pacific Railway Company, these rates have been reduced to \$1.25 and \$1.35 respectively.

### **Selling Cost of Peat Fuel at Alfred.**

The cost of manufacturing one ton of peat fuel has been estimated on the basis of the fuel manufactured over a short period when plant No. 1 was operating at about normal capacity, but it is confidently hoped that the operations to be undertaken next season will confirm the estimate of \$3.50 as the price at which one ton of peat fuel can be sold f.o.b. Alfred. This figure, however, is liable to change when the expenses encountered during the entire working season is charged against the output of fuel manufactured during that time, but it is expected that the figure will not be increased, but slightly reduced.

### **Distribution of Moneys Expended.**

The following statement of expenditures requires no explanation other than has been incorporated in this report. In these statements all moneys expended up to the end of the season is accounted for. There are, however, certain outstanding accounts which have not yet been turned in, but these represent small amounts, and will be included in the next report.

Detailed information can be obtained by referring to sheet No. 1, which shows the distribution of time during the period Plant No. 1 was operated. Sheet No. 2 shows the following labour costs for Plants Nos. 1 and 2: namely, excavation, spreading, and extra men used for various purposes, and also fuel costs. From this it will be seen that the cost of one ton of fuel on the field for Plant No. 1, exclusive of overhead charges, is \$1.05, and for Plant No. 2, 60 cents. Sheet No. 3 shows the approximate cost of machines Nos. 1 and 2, and the estimated cost to replace same; harvesting equipment and siding, office tools, telephone, experimenting, manufacturing fuel, and Committee expenses. Sheet No. 4 gives, in detail, the different items which make up the cost of one ton of peat fuel f.o.b. cars. Sheets Nos. 5 and 6 are entitled "the trouble sheets for Plant No. 1," and give, in detail, the troubles which were experienced, and remarks concerning same. Sheets Nos. 7 and 8 give the same information for Plant No. 2. Sheets 9, 10, 11, and 12, show the approximate distribution of all moneys paid out by the Committee, from its appointment, to the end of 1919.

With the assistance of this information, the work accomplished during the season of 1919, can be appreciated.



DISTRIBUTION OF TIME.

Peat Committee Investigations, 1919.

Plant No. 1 only.

SHEET No. 1.

Days of month	June				July.				August.				September.			
	Possible hours	Lost by rain.	Unproductive hours.	Productive hours.	Rows peat laid.	Possible hours.	Lost by rain	Unproductive hours	Productive hours.	Rows peat laid.	Possible hours	Lost by rain.	Unproductive hours	Productive hours.	Rows peat laid.	
1						10		4	6	3½	10		5	5	3	10
2						10		4	6	3½	10		2½	7½	4	10
3						10		4½	5½	2½	10			3½	6½	4½
4						10		6	4	2	10		4½	5½	3½	10
5						10	5	2½	2½	3½	10		3	5	2	10
6						10		2½	2½	3½	10		3½	6½	3½	10
7						10		3½	6½	4	10		5	5	3	10
8						10		3½	6½	3½	10		9½	1½	1	8½
9						10		7	3	1	10		3½	6½	3	10
10						10	2	4½	3½	1½	10		3½	6½	3	10
11						10	10				10		3½	6½	3	10
12						10		3	7	3½	10		3½	6½	4	10
13	10		3	7	2	10					10		3	7	3	10
14	10		4	6	2	10		4	6	3½	10		5½	4½	2½	10
15						10	10				10		5½	4½	3	5
16	10		4	6	2½	10		9	1		10		5½	4½	3	10
17	10		4	6	3	10		3	7	1	10		7	3	2	10
18	10		5	5	1½	10		10			10	6	1	3	2	10
19	10		8	2	1	10		10			10		2	8	3	10
20	10		7	3	1½	10					10		4½	5½	3½	10
21	10		5	5	2½	10		3½	6½	3	10		5	5	2	10
22						10		3	7	4½	10		2½	7½	3	10
23	10		4½	5½	1½	10		4	6	3½	10		4½	5½	4	10
24	10		8	2	1	10		8	2	1	10					10
25	10		3½	6½	3	10		10			10		8½	1½	1½	10
26	10	10				10		10			10		10			10
27	10		2½	7½	4½	10					10		10			10
28	10		3	7	3	10		2½	7½	4	10		10			10
29						10		5	5	2	10		10			10
30			4	6	3½	10		10			10		10			10
31						10		4½	5½	2½	10					10
	150	10	65½	74½	32½	270	27	139	104	53	260	6	148½	110½	62½	125
																31
																50
																44
																25½

One row contains 11 tons. Total produced about 1,900 tons. Average production per hour, June 4.5 tons, July 5.6 August 6.2, Sept. 6.4



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## Memorandum re Costs.

ALFRED BOG.

## Operating Costs.

SHEET No. 2.

Labour Capacity.	Plant No. 1. No. men.	Per Hour Rate.	Amount.	Plant No. 2. No. men.	Rate.	Amount.
<i>Excavator</i>		\$ cts.	\$ cts.		\$ cts.	\$ cts.
Engineer	1	0 60	6 00	1	0 60	6 00
Fireman	1	130.00 mo.	5 00	1	0 35	3 50
Runner	1	0 35	3 50	1	0 40	4 00
Attendant	1	0 30	3 00	2	0 30	6 00
<i>Spreading</i>						
Load cars	3	0 30	9 00		None	
Attending spreader	3	0 30	9 00	1	0 30	3 00
Move rails	2	0 30	6 00		None	
<i>Extra men</i>						
Clear in front of spreader and steer.	1	0 30	3 00		None	
Repair cars, etc.	1	0 35	3 50		None	
Water boy.	$\frac{1}{2}$	0 17 $\frac{1}{2}$	0 90			0 90
	Totals.		48 90			23 40
Fuel—1 $\frac{1}{2}$ tons coal—3 tons peat each plant			12 00			12 00
Gasoline—3 gals. No. 1			1 25			
Oil—estimated.			1 00			1 00
	Totals.		63 15			36 40
Average actual capacity to date.			60 tons.			60 tons.
Cost per ton.			\$1 05			0 60

\*This man may be dispensed with.

## Memorandum re Expenditures.

SHEET No. 3.

NOTE.—Amounts below are approximate. Accurate figures cannot be obtained until all expenditures are distributed.

Item.	Approx. actual cost.	Est. cost to replace.
<i>Machines</i>	\$	\$
No. 1	32,000	25,000
No. 2.	26,000	20,000
<i>Harvesting equipment and siding—</i>		
Truck		
Cars		
Locomotive	13,000	13,000
Loading platform.		
Siding		
<i>Office, tools, phone, etc.</i>	1,500	1,500
<i>Experimenting</i>	5,000	
<i>Making fuel</i>	9,000	
<i>Committee expenses—</i>		
Salaries.	12,600	
Other expenses.	10,400	
Miscellaneous.	5,000	
	114,500	Say 60,000



Overhead Cost.

SHEET No. 4.

Capital expenditure, estimated .....	\$ 60,000
Working capital.....	25,000
Depreciation, say 10% on \$60,000.....	\$ 6,000
Amortization, say 10% on \$60,000.....	6,000
Superintendent and mechanic.....	4,000
Office and stenographer.....	1,500
Incidentals, insurance, taxes, etc.....	1,500
	<u>\$ 19,000</u>

Estimated Production.  
Two plants—day and night, 100 days.  
Capacity, average 125 tons per day of 24 hours each per unit.  
Total estimated production, say 20,000 tons.  
Overhead, say \$1 per ton.

TOTAL COST.

Cost raw material, per ton.....	05		05
Production cost No. 1.....	1 05	No. 2.	0 60
Cubing and turning.....	0 30		0 30
Loading on cars or to store.....	0 60		0 30
Overhead.....	1 00		1 00
Total per ton.....	\$ 3 00		\$ 2 25
Average cost f.o.b. cars or in storage.....	\$ 2 62½ per ton		
Add for loading one half fuel second time from storage to pile 25c. per ton average.....	12½		
Average cost season output f.o.b. cars.....	\$ 2 75		

Trouble Sheet, Plant No. 1, 1919.

SHEET No. 5.

ITEM IN ORDER OF IMPORTANCE.

Item.	Remarks.
1. Supporting caterpillars. Driving mechanism broken. Difficulty with clutches. 124 chain broken. Excavator out of line.	These difficulties were practically entirely eliminated when the driving mechanism was rebuilt and latterly a differential drive installed.
2. Spreader, chain broken. Spreader sill broken. Spreader clutches slipping. Sprocket broken. Trouble with engine. Delay in turning.	The No. 1 spreader is being rebuilt with special attention to the weaknesses disclosed. Trouble with the engine was almost entirely due to stopping and starting so frequently due to the clutches which never worked satisfactorily. The drive chain will be replaced with a much stronger one and provision made so two men can turn the spreader in half the time it took five or six to do it in 1919.
3. Spreader cars driving mechanism. Cable slipping. Cable broken. Grips worn out.	Due almost entirely to original cable being too small. This was replaced by a larger cable and specially hardened grips procured and this trouble practically disappeared.
4. Spreader cars system. No cars available to load. Cars off track.  Station car off track. Station car anchor pulled.	Four new cars are ordered which should materially increase capacity of plant. Mostly at joints in track on spreading side of rectangle. An extra tie will be put in at these joints which will overcome this.  The original scheme of holding the station car was defective. This was changed by bracing it direct from the excavator and the trouble disappeared entirely.
5. Excavator chain and pins.	The original pins holding the excavator chain together were poorly designed and wore so that occasionally a pin came out. New pins of better design have been secured and in place.



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## Trouble Sheet, Plant No. 1, 1919.—Continued.

SHEET No. 6.

Item.	Remarks.
6. Soft ground. Caterpillars in a hole. Pivot castings No. 4 caterpillar broken.	The south end of the No. 1 drying field was never cross drained and was very soft in places even along the face. Drains have been put in to remedy this, and the carrying ties on two of the caterpillars will be increased 50 per cent in length, which should prevent further trouble from this cause.
7. Ordinary delays. Iron in macerator. Roots in conveyer. Wait for fuel. Wash boiler. Piston rod loose. Heater tube blew out. Pump gland played out. Repair dry pipe. Weather.	Delays from iron in macerator were few and coupled with delays from roots in conveyer were not very important. Care on the part of the attendants will remedy to an extent. Delays for fuel should disappear when a regular supply of peat is arranged for. Washing boiler should be done on Sundays. The next four items are not important, and are the ordinary hazards of running machinery of this kind. Delays due to weather are not as serious as might be imagined, as the men will work through any ordinary rain, and fuel may be laid out although the drying course is interfered with.

## ITEMS IN ORDER OF IMPORTANCE.

SHEET No. 7.

1. Supporting caterpillars driving mechanism broken. Difficulties with clutches. 124 chain broken. EC62 chain broken. Steering.	Difficulty with driving mechanism overcome when this was rebuilt. Difficulty with clutches and steering overcome by use of line to steer by and introduction of differential drive. Driving mechanism has also been raised so chains and sprocket wheels all run clear of moss. When work was commenced several drives were down in the peat most of the time.
2. Conveyer bridge caught on moss. Driving mechanism stalled in moss. Universal joint broken. Trouble with chain drives.	Practically all trouble with the bridge was due to it being too low. This has been raised one foot and a new connection with the platform made in the centre instead of at one end, which will eliminate these troubles.
3. Machine sinking in bog.	Until working face was cut down sufficient to get some drainage the bog was all very soft and many delays and breaks occurred. As the working face became deeper these gradually disappeared, but to eliminate this trouble entirely the supporting caterpillars have been increased 50 per cent in supporting area, which should eliminate this trouble even under such conditions as were met at the start.
4. Feed to belt insufficient.	The feeding mechanism to the belt conveyer at no time during the season had enough capacity to take the material away from the macerator. This has been altered to eliminate this trouble entirely.
5. Macerator repairs.	Due to running macerator light when the cut was first started some of the knives froze in their bearings. Some delays were due to this cause but they disappeared as soon as a normal supply of raw peat was available.

SHEET No. 8.

6. Excavator element. Pin work. Cutters broken. Supporting frame and driving shaft bent.	In the early part of the operations when the dry top surface of the bog was being excavated the excavator was subject to abnormal wear. The ends of the pins in the chain wore off and the pins came out from time to time. These have been replaced with new pins of much better design. Many roots were also encountered at first and a number of cutters broken and due to inexperience was permitted to stall on a root and the machine to move ahead which strained it badly. A new brace has been added which will prevent this happening again, and spare cutters provided, although the experience with No. 1 working on a proper face shows only a couple of cutters broken in the season.
7. Clutch controls.	Owing to this plant being so new no attempt was made to put in proper clutch controls until it was found where would be the best place to locate them. These will be put in for the 1920 season.



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Trouble Sheet, Plant No. 1, 1919.—*Concluded.*

Item	Remarks.
8. Delay turning spreader.	Serious delay in this operation was encountered at the start. Conditions gradually became better but a new method of handling it has been worked out which should reduce the time for this operation from several hours to possibly 20 minutes.
9. Sundry delays. Wait for fuel. Wait for water. Iron in macerator. Belt slipping. Adjust engines. Excavator caught on roots. Roots in spreader. Weather.	The main delays under this heading were mainly due to starting up on the new face with no proper organization. A lot of delay was caused from trouble in getting water to the boiler, which disappeared as the working ditch became deeper. The belt slipping was due to the bridge being too low, preventing proper adjustment of the parts. Roots in spreader was a minor trouble which should be eliminated by changes which have been made in the spreader.

## Committee Business.

SHEET No. 9.

<i>Salaries—</i>		
E. V. Moore, Engineering and Management.....	.....\$	11,180 65
Inspection .....		1,800 00
Superintendence.....		2,000 00
Drawing and designing.....		1,266 60
		<u>\$ 16,246 25</u>
<i>Travelling expenses—</i>		
Committee Members.....	\$	1,191 63
E. V. Moore.....		2,406 25
F. O. Orr.....		790 21
A. Anrep.....		268 24
A. Leverin.....		370 00
		<u>5,026 33</u>
<i>Rent.....</i>		1,140 00
<i>Office expenses—</i>		
Telephone and telegrams. Includes installation of Bell phone at Alfred.....		345 81
Stamps.....		91 57
Stationery, drawing supplies, etc.....		271 25
General.....		94 55
		<u>803 18</u>
		<u>\$ 23,215 76</u>

## PLANT AND EQUIPMENT.

SHEET No. 10.

<i>Plant No. 1—</i>		
Original cost.....	\$	28,373 16
Unload and install.....		895 05
Experimental work and alterations, materials.		1,548 46
Labour.....		731 36
		<u>\$ 31,548 03</u>
<i>Plant No. 2—</i>		
Original cost.....	\$	21,747 04
Unload and install.....		59 57
Experimental work and alterations, materials.		1,044 03
Labour.....		2,596 93
		<u>26,047 57</u>
<i>Harvesting and Loading Equipment—</i>		
Materials.....		11,127 87
Labour and install.....		1,526 94
		<u>12,654 81</u>
<i>Buildings and Telephone—</i>		
Materials.....		869 09
Labour on buildings.		359 20
Labour install telephone		26 35
		<u>1,254 64</u>
<i>Tools.</i>		583 77
<i>Freight and Expenses.</i>		1,738 71
		<u>\$ 73,827 53</u>



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SHEET No. 11.

## Operation Expenses.

*Plant No. 1*

Labour in excavation.....	\$ 169 80		
Operate excavator.....	251 17		
Operate boiler and engine.....	955 20		
Moving track.....	554 70		
Spreading.....	1,119 90		
		\$ 3,050 77	
Turn and cube contract.....	403 90		
Straight time.....	503 21		
		907 11	
Repairs.....		672 72	
			\$ 4,630 60

*Plant No. 2—*

Labour in excavation.....	12 60		
Operate excavator.....	154 68		
Operate boiler and engine.....	709 07		
Spreading.....	110 60		
		986 95	
Turn and cube		24 40	
Repairs.....		211 06	
			1,222 41

*Supplies—*

Coal.....	1,223 28		
Gasoline and oil.....	173 44		
Sundries.....	447 11		
Spare parts.....	395 24		
			2,239 07
Harvesting and loading		868 68	
Sundry repairs.....		170 00	
			\$ 9,130 76

SHEET No. 12.

## Other Expenses.

Prepare field for No. 1 plant.....	\$ 255 26		
Prepare field for No. 2 plant.....	894 60		
		\$ 1,150 06	
Water boy and general work.....		483 81	
Clean up property.....		401 86	
Move old plant..		215 55	
Sundries.....		1,225 74	
			\$ 3,477 02

## Summary.

Committee expenses.....	\$ 23,215 76
Plant and equipment.....	73,827 57
Operation.....	9,130 76
Other expenses.....	3,477 02
Cash advance to E.V.M.....	245 04
Cash on hand Alfred account.....	354 42
	\$ 110,250 53



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## ORE DRESSING AND METALLURGICAL DIVISION.

## I.

## REPORT OF PROGRESS.

W. B. TIMM, *Acting Chief of Division.*

Mr. G. C. Mackenzie, Chief of Division, resigned his position in February. The vacancy thus created was not filled during the calendar year. The writer has been acting as chief since Mr. Mackenzie's resignation.

Mr. R. K. Carnochan was appointed Assistant Engineer in January, to fill the vacancy created by the resignation of Mr. C. S. Parsons in May, 1918.

In the chemical laboratories, the loss of two temporary chemists, Mr. W. T. Graham, in May, and Mr. B. E. Coyne, in October, reduced the staff to two chemists. These vacancies remained unfilled at the end of the calendar year.

The resignations from the staff has resulted in the work being greatly curtailed especially during the latter part of the year.

In July, the writer was instructed to visit a number of ore dressing and metallurgical laboratories, such as the Experimental Stations of the United States Bureau of Mines, and the commercial testing works and industrial research laboratories in the United States, and report on his observations and their bearing on the proposed establishment of ore dressing and metallurgical laboratories at some point in British Columbia. Two months time was devoted to this work.

During the war period, the laboratories were busily engaged in the dressing and concentration of the ores from which war minerals were obtained, and on problems connected with the recovery of these minerals. During the calendar year laboratory work has been devoted entirely to the testing of Canadian ores and minerals, and to the application of ore dressing and metallurgical processes. With reference to the latter (application of new processes), special attention has been concentrated on the flotation of ores, and test work was, and is being conducted on these lines using certain substitutes for oil. This work has not advanced sufficiently for formal report.



## II.

## ORES TESTED AND REPORTS THEREON.

W. B. TIMM, *Acting Chief of Division.*R. K. CARNOCHAN, *Assistant Engineer.*

The following ores have been tested, and reports made thereon, during the calendar year, 1919:—

No. of Test.	Material.	Locality.	Shipper.	Weight.	
				Tons.	lbs.
105	Molybdenum-Gold Cobalt	New Hazelton, B.C.....	New Hazelton Gold—Cobalt Mines, Ltd., Vancouver, B.C.....	26	1,772
106	Magnetite	Cowichan Lake, B.C....	Canadian Munition Resources Comm., Ottawa.		430
107	Tungsten	Falcon Lake, Man..	War Metals Products Co., Winnipeg, Man.	3	1,953
108	Fluorite	British Columbia	Canadian Munition Resources Comm., Ottawa.		10
109	Platinum gold.	Caribou, B.C.....	Canadian Munition Resources Comm., Ottawa.		6
110	Chrome	British Columbia.....	Canadian Munition Resources Comm., Ottawa.		420
111	Lead-zinc	Kimberley, B.C....	Consolidated Mining & Smelting Co., Trail, B.C.		755
112	Tungsten	Dublin Gulch, Y.T.....	Frank Cantin, Esq., Dawson City, Y.T.		1,393
113	Graphite	Low, Que.	Robt. Bryce, Esq., Toronto.....	30	272
114	Iron	Clarendon, Ont.	Poe Mining Co., Clarendon Station, Ont.		200
115	Fluorite.....	Wallbridge Mines, Madoc, Ont.....	G. M. Wallbridge, Esq., Madoc, Ont....		300
116	Molybdenite.	Egan Tp., Wright Co., Que.	G. F. Creaghan, Esq., Ottawa, Ont.....		120
117	Silver	St. Catharines, Que.	Stinson-Reeb Builders Supply Co., Montreal, Que.....		200
118	Copper-nickel.	Sudbury, Ont.	Nicu-Steel Corporation, Ltd., Toronto, Ont.	1	
119	Tungsten.....	Dublin Gulch, Y.T.....	G. B. Mackenzie, Esq., Dawson City, Y.T.....		16
120	Pyrite.....	Caldwell Mine, Flower Station, Ont.	Grasselli Chemical Co., Ltd., Cleveland, Ohio.	10	
121	Manganese.....	Tenecape Mine, Kennet- cooke, Sta., N.S.....	A. A. Hassan, Esq., New York City....	1	
122	Barite	Lanark Co., Ont.	T. B. Caldwell, Esq., Lanark, Ont....		10
123	Fluorite.....	Maberly, Ont.	Geological Survey, Ottawa.....		96
124	Tungsten	Dublin Gulch, Y.T.	Wm. Steinberger, Esq., Dawson City, Y.T.		146
125	Molybdenite.....	Harvey, Ont.....	J. H. Teare, Esq., Sault Ste. Marie, Ont.		1,000
126	Graphite	Buckingham, Que.	Quebec Graphite Co., Buckingham, Que.	20	
127	Gold	Bingo Mine, The Pas District, Man.	M. R. Blake, Esq., Winnipeg, Man.....		68



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DETAILED PARTICULARS OF CONCENTRATION AND SEPARATION TESTS.

January 28, 1919.

Test No. 105.

A shipment of ore was received on August 6, 1918, from The New Hazelton Gold-Cobalt Mines, Ltd., New Hazelton, B.C.

This shipment consisted of 669 bags, which gave the following weights, analyses, and content:—

Net weight (wet).....	53,772 pounds.
Moisture—1.01 per cent.....	544 "
Dry net weight.....	53,228 "
Analysis—MoS <sub>2</sub> .....	1.40 per cent.
—MoO <sub>3</sub> .....	0.18 "
—Co.....	1.12 "
—Ni.....	0.60 "
—As.....	8.98 "
—Au.....	1.24 ozs.
Content—MoS <sub>2</sub> .....	745.19 pounds
—Co.....	596.15 "
—Ni.....	319.37 "
—As.....	4,779.87 "
—Au.....	33.00 ozs.

The object of the test work was to concentrate the values of the ore, and also obtain a separation of these values as far as practical. As the cobalt, nickel, arsenic, and gold values were intimately associated, it was feasible to concentrate these by water concentration, and also to obtain a separation and concentration of the molybdenite values by flotation.

The shipment was divided into three lots as follows:—

Lot No. 1.—Test No. 1, Dry net weight.....	12,144 pounds.
Lot No. 2.—Test No. 2, Dry dry weight.....	35,234 "
Lot No. 3.—Test No. 3, Dry net weight.....	5,850 "

*Lot No. 1, Test 1.*—The procedure was as follows: The ore was crushed to 20 mesh and concentrated on a Wilfley concentrator to remove as much as possible of the cobalt, nickel, arsenic, and gold values. Two products were made, a concentrate and tailing. The tailings were reground in a Hardinge mill to 60 mesh and the molybdenite concentrated by means of the Callow pneumatic flotation process. The flotation tailings were rerun over the Wilfley concentrator to further remove any cobalt, nickel, arsenic, and gold values.

*Lot No. 2, Test 2.*—The procedure was as follows: The ore was crushed to 40 mesh and concentrated on a Wilfley concentrator to remove as much as possible of the cobalt, nickel, arsenic, and gold values. Two products were made, a concentrate and tailing. The tailings were reground in a Hardinge mill to 80 mesh and the molybdenite concentrated by flotation in a Callow unit. The flotation tailings were rerun over the Wilfley concentrator and the tailings from the table were considered final and allowed to go to waste.

*Lot No. 3, Test 3.*—The procedure was as follows: The ore was ground in a Hardinge mill to 80 mesh and the molybdenite first floated in a Callow unit. The flotation tailings were concentrated on a Wilfley concentrator to remove the cobalt, nickel, arsenic, and gold values, and the tailings from the table pumped to waste.

This latter test was run to obtain a comparison of results between tabling followed by flotation, and flotation followed by tabling.

The results are contained in the attached tables.



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*Conclusions.*—From the attached summary, the actual recoveries made on this carload of ore were as follows:—

In Table Concentrates—	
Cobalt.....	72.6 per cent.
Nickel.....	87.5 "
Arsenic.....	84.9 "
Gold.....	83.5 "
In Flotation Products	
Molybdenite.....	54.4 "

These recoveries should be improved upon in practice where a closed circuit could be maintained and the losses due to handling and slime overflow would be reduced to a minimum.

As the molybdenum values are of secondary value as compared to the other metals present, it is advisable to remove as much as possible of the cobalt, nickel, arsenic, and gold values before flotation, to recover the molybdenite values. From the attached tables it is shown that most of these values can be removed at 40 mesh, and as it is necessary to grind it to 100 mesh to recover the molybdenite values it would not be wise to float first and table afterwards, as the loss in cobalt-nickel-arsenic-gold values due to fine grinding would not compensate for the higher recovery of the molybdenite.

From the test work conducted, the procedure to follow on the concentration of this ore would be as follows:—

The crude ore crushed in a jaw crusher to 1½ inch to 1 inch and ground in a wet ball mill in circuit with a classifier to about 40 mesh and concentrated on tables of the Wilfley type; the table tailings reground in a ball or tube mill to 100 mesh in circuit with a classifier and the molybdenite floated in an oil flotation unit; the tailings from the flotation unit concentrated on slime tables or vanners.



Concentration Tables—New Hazelton Gold—Cobalt Mines, Limited.

Product.	Mesh.	Weight.	Analysis.						Content.						Percentages of values.																				
			MoS <sub>2</sub>			MoO <sub>3</sub>			Co.			Ni			As.			Au.			MoS <sub>2</sub>			Co.			Ni			As.			Au.		
			%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.	%	Lbs.	ozs.			
Test No. 1.	Table Concentrates.....	20	1,574	1.00	5.42	3.14	51.00	7.55	15.74	85.31	49.42	802.74	9.3	5.94	62.7	67.8	73.6	78.9																	
	Flotation Concentrates...	60	155	52.28	0.53	0.27	3.52	1.50	81.03	0.82	0.42	5.46	47.6	0.116	0.6	0.6	0.5	1.5																	
	2nd Table Concentrates.	60	217	1.34	5.05	2.70	47.73	3.05	2.90	10.96	5.86	103.57	1.7	0.33	8.1	8.1	9.4	4.4																	
	Tailings.....	60	10,198	0.67	0.35	0.10	1.52	0.04	68.33	35.69	10.20	155.01	40.2	0.204	26.2	14.0	14.2	2.7																	
	Losses.....								2.02	3.23	0.96	23.75	1.2	0.94	2.4	9.5	2.3	12.5																	
Crude Ore.....				12,144	1.40	0.18	1.12	0.60	8.98	1.24	170.02	136.01	72.86	1,090.53	7.53	100.0	100.0	100.0																	
Test No. 2	Table Concentrates.....	40	4,725	2.20	6.05	3.95	55.15	7.80	103.95	285.86	186.64	2,605.84	21.0	18.43	72.5	88.3	82.3	84.4																	
	Flotation Concentrates...	80	569	53.47	0.60	0.25	3.31	1.35	304.24	3.41	1.42	18.83	61.7	0.38	0.9	0.7	0.6	1.7																	
	2nd Table Concentrates.	80	91	1.35	3.75	2.48	35.02	2.30	1.23	3.41	2.26	31.87	0.3	0.10	0.9	1.1	1.0	0.5																	
	Tailings.....	80	29,849	0.25	0.26	0.04	1.48	0.02	74.62	77.61	11.94	441.77	15.1	0.30	19.6	5.7	14.0	1.4																	
	Losses.....								9.23	24.33	9.14	65.70	1.9	2.63	6.1	4.2	2.1	12.0																	
Crude Ore.....				35,234	1.40	0.18	1.12	0.60	8.98	1.24	493.27	394.62	211.40	3,164.01	21.84	100.0	100.0	100.0																	
Test No. 3.	Flotation Concentrates...	80	94	58.29	0.78	0.47	4.50	6.60	54.79	0.73	0.44	4.23	66.9	0.31	1.1	1.3	0.8	8.5																	
	Table Concentrates.....	80	980	1.51	5.35	3.05	44.70	3.90	14.80	52.43	29.89	438.06	18.0	1.91	80.0	85.2	83.4	52.7																	
	Tailings.....	80	4,776	0.26	0.25	0.10	1.62	0.03	12.42	11.94	4.78	77.37	15.1	0.07	18.2	13.6	14.7	1.9																	
	Losses.....									0.42		5.67		1.337	0.7		1.1	36.9																	
	Crude Ore.....			5,850	1.40	1.12	0.60	8.98	1.24	81.90	65.52	35.10	525.33	3.627	100.0	100.0	100.0	100.0																	
Return of Flotation Concentrates	Table Concentrates.....		68	16.04	5.32	3.48	29.80	23.40	10.91	3.62	2.37	20.26	†	0.80																					
	Flotation Conc. No. 1.....	+	250	70.20	0.22	0.08	1.20	0.02	175.50	0.55	0.20	3.00	†	0.0025																					
	Flotation Conc. No. 2.....	+	150	67.80	0.32	0.13	1.28	0.30	101.70	0.48	0.19	1.92	†	0.0225																					
	Flotation Middlings.....	+	350	36.63	0.78	0.37	4.86	0.20	128.21	2.73	1.29	17.01	†	0.035																					
	Losses.....								23.74	-2.42	-1.77	-13.67	†	0.054																					
Totals.....				818	53.80		0.61	0.28	3.49	0.20	440.06	4.96	2.28	28.52	0.806	†																			
Summary:	Table Concentrates.....	*	7,655	7.95	5.65	3.65	53.30	7.20	149.27	432.51	279.41	4,060.12	20.0	27.558	72.6	87.5	84.9	83.5																	
	Flotation Products.....	*	750	54.06	0.50	0.22	2.92	0.16	405.41	3.76	1.68	21.93	54.4	0.06	0.6	0.5	0.5	0.2																	
	Tailings.....		44,823	0.35	0.28	0.06	1.50	0.03	155.37	125.21	26.92	674.15	20.9	0.574	21.0	8.4	11.1	1.7																	
	Losses.....								35.14	34.64	11.36	23.67	4.7	4.808	5.8	3.6	0.5	14.6																	
	Crude Ore.....			53,228	1.40	1.12	0.60	8.98	1.24	745.19	596.15	319.37	4,779.87	33.006	100.0	100.0	100.0	100.0																	

Note:—\*Final Concentration Products, Table Concentrates and Flotation Products. Flotation Products marked †, namely concentrates No. 1, No. 2 and middlings. †These Results do not check with the totals given in last line of this table which are the totals of Flotation Concentrates from Tests, 1, 2 and 3, because there was a small accumulation from the three tests remaining in the cells which was rerun with Flotation Concentrates.



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Ottawa, February 5, 1919.

## Test 106.

A shipment of 430 pounds of manganese ore in two lots was received on October 22, 1918, from Cowichan lake, Vancouver island, B.C.

*Lot No. 1* consisted of three sacks from the Black Prince claim, and gave the following analysis:—

Metallic Manganese . . . . .	22.09 per cent.
" Iron . . . . .	3.22 "
Silica . . . . .	58.16 "
Phosphorus . . . . .	0.061 "
Sulphur . . . . .	0.165 "

*Lot No. 2* consisted of one sack from the Pacific claim, and gave the following analysis:—

Metallic Manganese . . . . .	15.66 per cent.
" Iron . . . . .	6.39 "
Silica . . . . .	66.92 "
Phosphorus . . . . .	0.089 "
Sulphur . . . . .	0.166 "

Concentration tests by jigging and tabling were made on these two lots to determine whether the ore could be treated successfully in this manner.

Each lot was crushed to pass 3 mesh or to  $\frac{1}{4}$ -inch size, and sized on 6, 12, 20, and 30 mesh screens; the sizes coarser than 30 mesh were jigged while the sizes through 30 mesh were tabled.

The weights and analyses of the resulting products were as follows:—

*Lot No. 1—*

Mesh.	Product.	Weight Lb.	Per cent Mn.	Per cent Fe.
— 3+ 6	Jig concentrates . . . . .	17.7	27.00	2.68
— 3+ 6	" tailings . . . . .	1.60	19.40	2.50
— 6+12	" concentrates . . . . .	12.0	32.74	2.40
— 6+12	" tailings . . . . .	17.0	19.44	2.50
—12+20	" concentrates . . . . .	7.0	25.07	1.70
—12+20	" tailings . . . . .	17.5	21.70	1.70
—20+30	" concentrates . . . . .	7.0	24.63	0.74
—20+30	" tailings . . . . .	7.5	23.20	0.79
—30	Table concentrates . . . . .	4.5	37.45	1.00
—30	" tailings . . . . .	24.0	19.78	0.70

*Lot No. 2—*

Mesh.	Product.	Weight Lb.	Per cent Mn.	Per cent Fe.
— 3+ 6	Jig concentrates . . . . .	7.5	26.65	4.25
— 3+ 6	" tailings . . . . .	34.5	12.30	4.20
— 6+12	" concentrates . . . . .	2.5	25.33	3.40
— 6+12	" tailings . . . . .	14.5	12.87	3.52
—12+20	" concentrates . . . . .	2.5	20.84	2.70
—12+20	" tailings . . . . .	3.5	11.59	2.85
—20+30	" concentrates . . . . .	0.5	16.65	1.25
—20+30	" tailings . . . . .	2.5	16.31	1.50
—30	Table concentrates . . . . .	0.5	32.12	2.65
—30	" tailings . . . . .	4.0	14.87	1.40

*Conclusions.*—The above results show conclusively that the ore cannot be concentrated by specific gravity methods, using jigs and tables. A partial separation was made, but the ratio of concentration was very small, and the percentage of manganese in both concentrates and tailings unsatisfactory.



10 GEORGE V, A. 1920

Ottawa, January 9, 1919.

Test No. 107.

A shipment of scheelite ore was received on November 15, 1918, from "The War Metals Products Company," Winnipeg, Man.

This shipment was from the Falcon Lake district, and consisted of 90 bags, having the following weights, analysis, and content:—

Gross weight...	7,921 pounds.
Net weight...	7,921 "
Moisture, 0.40%	32 "
Net dry weight	7,921 "
Analysis—WO <sub>3</sub> ...	1.65 per cent.
MoS <sub>2</sub> ...	0.10 "
Au...	None.
Content—WO <sub>3</sub> ...	130.70 pounds.
MoS <sub>2</sub> ...	7.92 "

The mineral constituents of the ore were scheelite (calcium tungstate), molybdenite (molybdenum sulphide), and pyrite (iron sulphide). The rock constituents were a green coloured mineral, probably olivine; a dark coloured mineral, hornblende, and calcite.

Concentration tests were conducted to recover the tungsten values in the form of scheelite concentrates. No attention was paid to the molybdenite, as it was present in such small quantities.

The ore was crushed to 20 mesh in a dry ball mill, and fed by a push feeder to a Wilfley concentrator, water being added below the feeder to obtain the required pulp density for the table. From the concentrator three products were made, a concentrate, middling, and tailing, of the following weights, analyses, and content:—

Concentrates...	146 pounds.
Analysis, WO <sub>3</sub> ...	70.90 per cent.
Content, WO <sub>3</sub> ...	103.51 pounds.
Percentage of WO <sub>3</sub> values...	79.3 per cent.
Middlings...	860 pounds.
Analysis, WO <sub>3</sub> ...	2.90 per cent.
Content, WO <sub>3</sub> ...	24.94 pounds.
Percentage of WO <sub>3</sub> values...	19.0 per cent.
Tailing to waste...	6.915 pounds.
Analysis, WO <sub>3</sub> ...	0.04 per cent.
Content, WO <sub>3</sub> ...	2.76 pounds.
Percentage of WO <sub>3</sub> values...	2.1 per cent.

The middlings from the table were reground to 50 mesh and concentrated on the table. Two products were in this case, a concentrate, and tailing, of the following weights, analyses, and content:—

Concentrates...	31 pounds.
Analysis, WO <sub>3</sub> ...	69.34 per cent.
Content, WO <sub>3</sub> ...	21.50 pounds.
Percentage of WO <sub>3</sub> values...	16.4 per cent.
Tailings to waste...	829 pounds.
Analysis, WO <sub>3</sub> ...	0.35 per cent.
Content, WO <sub>3</sub> ...	2.90 pounds.
Percentage of WO <sub>3</sub> values...	2.2 per cent.

Summary.—The following is a summary of the results of the concentration of this shipment of scheelite ore:—

	Crude ore.	Concentrates.	Tailings.
Weights, lb...	7,921	177	7,744
Analysis, WO <sub>3</sub> ...	1.65%	70.63%	0.073%
Content, WO <sub>3</sub> , lb...	130.70	125.01	6.69
Percentage of WO <sub>3</sub> values...	100.0%	95.7%	1.3%



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*Conclusions.*—From the above test a high grade tungsten concentrate of grade 70.63 per cent was made, with a recovery of 95.7 per cent of the tungsten values in the ore. These results are very satisfactory for a low grade ore, considering the comparatively coarse crushing necessary to obtain the separation. This is a very favourable point, as it eliminates the slime loss due to fine crushing. A clean tailing can be discarded at 20 mesh, leaving a small percentage of middling product to be reground.

*Ottawa, February 4, 1919.*

## Test No. 108.

A small sample of 10 pounds of fluorite was received on November 18, from Dr. Ferrier, of the Canadian Munition Resources Commission.

This sample was crushed to 50 mesh and a small sample taken for analysis which gave the following:—

Calcium fluoride— $\text{CaF}_2$ .. . . .	47.20 per cent.
Calcium carbonate— $\text{CaCO}_3$ .. . . .	2.50 "
Strontium sulphate— $\text{SrSO}_3$ .. . . .	32.30 "
Silica — $\text{SiO}_2$ .. . . .	6.50 "
Iron sulphide— $\text{FeS}_2$ .. . . .	3.70 "
Alumina— $\text{Al}_2\text{O}_3$ .. . . .	3.00 "
Magnesia.. . . .	present.
Undetermined.. . . .	4.80 per cent.

As the analysis shows, 3.70 per cent of iron sulphides were present. Small tests were made by table concentration and flotation to remove these sulphides.

Analysis of the table product showed:—

Fe.. . . .	0.90 per cent.
$\text{FeS}_2$ .. . . .	1.94 "

Analysis of the flotation product showed:—

Fe.. . . .	0.50 per cent.
$\text{FeS}_2$ .. . . .	1.07 "

Table concentration removed the coarse pyrite, but a percentage of the fine pyrite slimed and was carried over into the fluorite product.

Flotation concentration removed the fine pyrite, but a percentage of the coarse pyrite was too heavy to float satisfactorily and remained in the fluorite product.

A combination of table and flotation concentration should give satisfactory results.

*Ottawa, March 3, 1919.*

## Test No. 109.

A sample of about six pounds of platinum-gold concentrates was received from the Bullion Mines, Cariboo District, B.C., through the Canadian Munition Resources Commission.

This sample was submitted for testing amalgamation of the platinum group of metals by a new method which consisted of sprinkling zinc amalgam on the dressed plates, the pulp being fed over the plates in a weak solution of copper sulphate and sulphuric acid. An electro-chemical action takes place, forming a permanent coating of copper on the platinum, which in passing over the plates is held by the mercury.

One-half of the sample received was taken and crushed to 150 mesh. A sample was cut out for assay. One pound of the material through 150 mesh was placed in a bottle, with 200 c.c. of a 0.05 per cent copper sulphate and a 0.05 per cent sulphuric



acid solution. One-tenth of a pound of mercury, to which had been added 1 gram of powdered zinc amalgam, was put in the bottle and the bottle gently rolled for 10 minutes. The contents of the bottle were then panned to recover the mercury, and the tailings sampled and assayed.

The results of this test were as follows:—

Pulp before amalgamation. . . . .	Au.—0.25 oz.	Pt.—0.013 oz.
Pulp after amalgamation.. . . .	Au.—0.15 oz.	Pt.—0.006 oz.
Retort sponge.. . . .	Au.—0.14 oz.	Pt.—0.004 oz.
Extraction.. . . .	Au.—40 per cent	Pt.—54 per cent.

Another pound sample was taken of the 150-mesh material and placed in the bottle with 200 c.c. of 0.1 per cent copper sulphate and 0.1 per cent sulphuric acid solution. One-tenth of a pound of mercury to which was added 1 gram of powdered zinc amalgam was put in the bottle and the bottle gently rolled for ten minutes. The contents of the bottle were panned to recover the mercury, and the tailings sampled and assayed.

The result obtained from this test was similar to the preceding one.

The tailings from these two tests were then put into a pebble jar with 400 c.c. of 0.1 per cent copper sulphate and 0.1 per cent sulphuric acid solution. One-fifth of a pound of mercury, to which was added 2 grams of powdered zinc amalgam, was put in the jar and the whole revolved for one hour. The contents were then panned to recover the mercury and the tailings sampled and assayed.

The results were as follows:—

Pulp before amalgamation. . . . .	Au.— 0.12 oz.	Pt.— 0.007 oz.
Pulp after amalgamation.. . . .	Au.— 0.10 oz.	Pt.— 0.005 oz.
Extraction... . .	Au.—17 per cent.	Pt.—30 per cent.
Or a further extraction of.. . . .	Au.— 8 per cent.	Pt.—15 per cent.

The remaining portion of the original concentrate was then ground to 200 mesh and sampled for assay. One side of a set of standard amalgamation plates was partitioned off and the plates dressed. The upper two plates were sprinkled with powdered zinc amalgam. A quantity of 0.2 per cent copper sulphate and 0.2 per cent sulphuric acid solution was made up and fed with the pulp over the plates. The tailings were panned to remove any mercury which had been carried over, and then sampled and assayed.

The results of the test were as follows:—

Pulp before amalgamation... . .	Au.— 0.10 oz.	Pt.— 0.003 oz.
Pulp after amalgamation.. . . .	Au.— 0.06 oz.	Pt.— 0.001 oz.
Extraction.. . . .	Au.—40 per cent	Pt.—66 per cent.

*Summary and conclusions.*—Results of the last test performed in a commercial way were similar to the bottle tests. There is a large variation in the two head samples of the same material, illustrating the difficulty in getting an accurate sample. The accuracy of the above tests is doubtful owing to the low assay of the material on which the tests were conducted.

Ottawa, March 3, 1919.

Test No. 110.

A shipment of 420 pounds, in two boxes, of chrome ore was received on December 24, 1918, from Dr. Ferrier, of the Canadian Munition Resources Commission.

On examination the chromite was found to be finely crystalline, much more so than the Black Lake chromite, necessitating finer grinding to free it from the gangue. The gangue consisted of serpentine. Iron pyrites was also present in the ore.



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The ore was crushed to 50 mesh and sampled for analysis, which gave the following:—

Cr<sub>2</sub>O<sub>3</sub>... .. 10.7 per cent.

A small preliminary test was run on 24 pounds on a small Wilfley table. The weights, analysis, and content of the products were as follows:—

Ore taken.. ..	24 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	10.7 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	2.57 pounds.
Concentrates obtained.. ..	3.0 pounds.
Analysis.... Cr <sub>2</sub> O <sub>3</sub>	47.34 per cent.
	S 2.40 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	1.42 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	55.3
Middlings obtained.. ..	1.5 pounds.
Analysis.. .. Cr <sub>2</sub> O	12.75 per cent.
Content.. .. Cr <sub>2</sub> O	0.19 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	7.5
Tailings obtained.. ..	12.5 pounds.
Analysis.. .. Cr <sub>2</sub> O	4.56 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	0.57 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	22.2
Slime loss.. ..	7.0 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	5.56 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	0.39 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	15.0

A larger test was then conducted on the remainder of the ore on the large Wilfley table. Two grades of concentrates were cut out, a middling held, and a tailing run to waste after being sampled. The results were as follows:—

Weight of ore taken.. ..	390 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	10.70 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	41.73 pounds.
First concentrates.. ..	37.0 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	48.88 per cent.
	S 2.20 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	18.09 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	43.4 "
Second concentrates.. ..	29 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	42.10 per cent.
	S 1.13 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	12.21 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	29.3
Middlings.. ..	11 pounds.
Analysis.. .. Cr <sub>2</sub> O	17.00 per cent.
Content.. .. Cr <sub>2</sub> O	1.87 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	4.5 per cent.
Tailings and slime loss.. ..	313 pounds.
Analysis.. .. Cr <sub>2</sub> O <sub>3</sub>	3.05 per cent.
Content.. .. Cr <sub>2</sub> O <sub>3</sub>	9.56 pounds.
Percentage of Cr <sub>2</sub> O <sub>3</sub> values.. ..	22.8

Tailings as samples, which does not include slime loss, showed an analysis of 2.51 per cent Cr<sub>2</sub>O<sub>3</sub>.

*Summary and conclusions.*—The above results show that the chrome values are practically all freed from the gangue at 50 mesh; that a satisfactory separation can be made by water concentration on tables resulting in a recovery of 72.7 per cent of the chromite values, in concentrates of first grade 48.88 per cent Cr<sub>2</sub>O<sub>3</sub>, and second grade 42.10 per cent Cr<sub>2</sub>O<sub>3</sub>. Both these grades are metallurgical products and can be used for reduction to ferro-chrome, but on account of the iron sulphide present in the ore, which reports in the concentrates by water separation on tables, they could not be classed as a chemical product.



10 GEORGE V, A. 1920

Ottawa, March 19, 1919.

Test No. 111.

A shipment of six sacks, containing 645 pounds of heat-treated Sullivan ore, was received on January 8, 1919, from the Consolidated Mining and Smelting Company, Limited, of Trail, B.C. Previous shipments of this ore consisted of a 10-pound sample and also a sack containing about 100 pounds.

The object of the test work was to determine whether a satisfactory separation could be made of the zinc-lead values from the iron by the use of the Grondal wet magnetic separator.

For a preliminary test the 100-pound lot was taken and ground to the following:—

On 200..	45 per cent.
Through 200	55 per cent.

A sample was cut out which gave the following analysis:—

Fe..	30.20 per cent.
Zn..	20.00 per cent.
Pb..	13.35 per cent.

The Grondal separator was adjusted so that the feed in passing over the bridge in the magnetic field would be as close to the magnets as possible. The strongest field possible for our installation was used, namely 6.5 amperes × 110 volts.

Ninety-five pounds of the heat-treated ore ground to the fineness given above was fed to the separator, and the magnetic and non-magnetic products caught. Very little magnetic product was obtained, so little that the test was considered a failure.

The non-magnetic product from the Grondal separation was run through the Ullrich magnetic separator. A separation was here made, so it was decided to make a test run on the heat-treated ore, through this separator.

For this test the shipment of 645 pounds was taken, and crushed to the fineness given in the screen test of the table. It was then cut in two, one lot held and the other sampled down for analysis and for the test run. The following is the analysis of the ore to the separator:—

Fe..	30.80 per cent.
Zn..	21.18 per cent.
Pb..	12.17 per cent.

The rings on the separator were adjusted as follows:—

Ring 1..	3/4-inch from feed plate.
Ring 2..	5/8-inch from feed plate.
Ring 3..	1/2-inch from feed plate.
Ring 4..	3/8-inch from feed plate.

The magnetic field obtained was from a current strength of 10 amperes by 110 volts.

Six products were made, a magnetic product from each ring, and two non-magnetic products, namely, a middling and zinc-lead product. The results of this separation are given in the table.

The magnetic products were reground to the fineness given in the screen tests of the table, and rerun through the separator. The results of these runs are also given in the table, as well as a summary of the separation on this ore.



Magnetic Separation of Heat-treated Sullivan Ore—Ullrich Four-pole, Four-ring Magnetic Separator.

FIRST SEPARATION ON HEAT-TREATED ORE.

Screen Test.				Separation.												
Tyler Standard.	Weight, Grams.	Per cent.	Cumulative per cent.	Product.	Weight, Lbs.	Analysis.				Content.				Percentages.		
						Fe.	Zn.	Pb.	Ph.	Lbs. Fe.	Lbs. Zn.	Lbs. Pb.	Fe.	Zn.	Pb.	
+65	5	0.2		Ring No. 1	73.5	52.0	5.57	5.10		38.220	4.094	3.748	11.3	6.4	10.2	
-65+100	128	6.0	0.2	Ring No. 2	7.0	49.6	6.22	5.57		3.472	0.442	0.390	3.8	0.7	1.1	
-100+150	459	21.7	6.2	Ring No. 3	35.0	50.6	6.11	5.54		17.710	2.138	1.939	19.1	3.4	5.3	
-150+200	680	32.1	27.9	Ring No. 4	51.0	30.9	22.02	9.89		15.759	11.230	4.998	17.0	17.6	13.7	
-200	847	40.0	60.0	Middlings	20.5	12.0	31.00	21.35		2.460	6.367	4.377	2.7	10.0	12.0	
			40.0	Zinc-lead	93.5	11.6	3.80	18.80		10.846	31.634	17.606	11.7	49.7	48.1	
				Slime loss	20.0	20.4	38.72	17.50		4.087	7.744	3.513	4.4	12.2	9.6	
Totals...	2,119	100.0		Totals	300.5	30.8	21.18	12.17		92.554	63.646	33.571	100.00	100.0	100.0	

SEPARATION OF RING NO. 4 FROM OTHER REMAINING.

+100	1	0.1	0.1	Ring No. 1	2.50	54.05	3.91	4.12		1.486	0.108	0.113	9.5	0.9	2.3	
-100+150	39	5.5	5.6	Ring No. 2	0.25											
-150+200	96	13.7	19.3	Ring No. 3	9.06	55.05	3.57	4.02		4.954	0.321	0.262	31.6	2.9	7.3	
-200	567	80.7	80.7	Ring No. 4	11.00	43.35	12.97	4.65		4.798	1.427	0.513	37.4	12.8	10.3	
				Middlings	4.50	16.60	34.45	11.51		3.403	7.062	2.360	21.7	63.2	47.4	
				Zinc-lead	16.00	14.28	30.09	21.67		1.071	2.257	1.625	6.8	20.2	32.7	
				Slime loss	7.50											
Totals...	703	100.0		Totals	50.75	50.90	22.02	9.80		15.682	11.175	4.973	100.0	100.0	100.0	

SEPARATION OF RING NO. 3 FROM OTHER REMAINING.

+100	0.5	0.1	0.1	Ring No. 1	16.0	56.60	2.25	3.44		9.62	0.382	0.585	55.1	18.1	50.6	
-100+150	17	3.6	3.7	Ring No. 2	1.0											
-150+200	49	10.4	14.1	Ring No. 3	7.5	57.15	2.05	2.70		4.286	0.154	0.292	24.5	7.3	10.6	
-200	405	85.9	85.9	Ring No. 4	3.5	53.95	5.04	2.97		1.888	0.170	0.104	10.8	8.4	5.4	
				Middlings	1.0	23.85	25.60	16.44		0.954	1.024	0.658	5.5	18.6	34.4	
				Zinc-lead	3.0	28.28	14.88	14.48		0.707	0.372	0.362	4.1	17.6	19.0	
				Slime loss	2.5											
Totals...	471.5	100.0		Totals	54.5	50.60	6.11	5.54		17.457	2.108	1.911	100.0	100.0	100.0	



Magnetic Separation of Heat-treated Sullivan Ore—Ullrich Four-pole, Four-ring Magnetic Separator.—(Concluded).  
SEPARATION OF RING No. 1 and No. 2 PRODUCTS AFTER REGRINDING.

Screen Test.			Separation.											
Tyler Standard.	Weight. Grams.	Per cent.	Cumulative per cent.	Product.	Analysis.			Content.			Percentage.			
					Weight Lbs.	% Fe.	% Zn.	% Pb.	Lbs. Fe.	Lbs. Zn.	Lbs. Pb.	Fe.	Zn.	Pb.
+100	0	0.0	0.0	Ring No. 1..	42.0	57.15	1.53	2.34	24.574	0.658	1.006	59.3	14.6	24.4
				Ring No. 2.....	1.0									
-100+150	18	3.3	3.3	Ring No. 3.....	16.5	56.80	1.70	2.14	9.372	0.280	0.353	22.6	6.2	8.6
				Ring No. 4.....	6.5	54.70	3.89	2.90	3.555	0.253	0.188	8.6	5.6	4.6
-150+200	52	9.7	13.0	Middlings...	3.5	26.05	23.19	15.49	2.344	2.087	1.394	5.7	46.4	33.9
				Zinc-lead	5.5									
-200	469	87.0	87.0	Slime loss.....	5.0	31.74	24.52	23.42	1.587	1.226	1.171	3.8	27.2	28.5
Totals...	539	100.0		Totals.....	80.0	51.79	5.63	5.14	41.432	4.504	4.112	100.0	100.0	100.0

SUMMARY.  
COMBINED IRON PRODUCTS.

Iron products represent '35 per cent by weight of original ore.	Rings Nos. 1 & 2 rerun of No. 4	2.75	54.05	3.91	4.12	1.486	0.108	0.113					
	Ring No. 3 rerun of No. 4	9.00	55.05	3.57	4.02	4.954	0.321	0.362					
	Rings Nos. 1 & 2 rerun of No. 3	17.00	56.60	2.25	3.44	9.622	0.382	0.585					
	Ring No. 3 rerun of No. 3	7.50	57.15	2.05	2.70	4.286	0.154	0.202					
	Ring No. 4 rerun of No. 3	3.50	53.95	5.04	2.97	1.888	0.176	0.104					
	Rings Nos. 1 & 2 rerun of Nos. 1, and 2..	43.00	57.15	1.53	2.34	24.574	0.658	1.006					
	Ring No. 3 rerun of Nos. 1 & 2.	16.50	56.80	1.70	2.14	9.372	0.280	0.353					
	Ring No. 4 rerun of Nos. 1 & 2	6.50	54.70	3.89	2.90	3.555	0.253	0.188					
	Totals.	105.75	56.49	2.21	2.75	59.737	2.332	2.913	65.0	3.7	8.0		

COMBINED ZINC-LEAD PRODUCTS.

Zinc products represent 49 per cent by weight of original ore.	Middlings first separation. ...	20.50	12.00	31.03	21.35	2.460	6.367	4.377					
	Zinc-lead first separation....	93.50	11.60	33.83	18.83	10.846	31.631	17.606					
	Mid.-zinc-lead rerun of No. 4.	20.50	16.60	34.45	11.51	3.403	7.062	2.350					
	Mid.-zinc-lead rerun of No. 3	4.00	23.85	25.60	16.44	0.954	1.024	0.658					
	Mid.-zinc-lead rerun of Nos. 1&2	9.00	26.05	23.19	15.49	2.344	2.087	1.394					
	Totals.	147.50	13.56	32.66	17.89	20.007	48.171	26.335	21.7	75.8	72.3		



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MIDDINGS PRODUCT.

4 per cent by weight, approx	Ring No. 4 Run No. 1	11.00	43.35	12.97	4.66	4.768	1.427	0.513	5.2	2.2	1.4
SLIME LOSS.											
Slime loss represents 12 per cent by weight approx. of original ore.	Slime loss first separation	20.00	20.40	38.74	17.56	1.087	7.744	3.513			
	Slime loss rerun of No. 1	7.50	14.28	30.09	21.67	1.071	2.257	1.625			
	Slime loss rerun of No. 3	2.50	28.28	14.88	14.48	0.707	0.375	0.362			
	Slime loss rerun of Nos. 1 & 2	5.00	31.74	24.52	23.42	1.587	1.226	1.171			
	Totals.	35.00	21.29	33.44	19.06	7.452	11.599	6.671	8.1	18.3	18.3



10 GEORGE V, A. 1920

Ottawa, April 15, 1919.

Test No. 112.

A shipment of 11 bags of scheelite concentrates was received on January 9, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from Frank Cantin, Esq., Mayo Landing, Yukon territory.

The concentrates were shipped from Mayo Landing and had been produced by placer mining. They contained, besides the scheelite, a certain amount of gold, this being in the form of metallic flakes of fair size.

A mill test was desired, to ascertain if the gold could be recovered from the scheelite concentrates by an economical process.

Gross weight of concentrates.. . . .	1,405 pounds.
Net weight of concentrates.. . . .	1,393 "
Head sample.. . . .	3 "
Net weight after sampling.. . . .	1,390 "
Moisture, at 0.32%.. . . .	5 "
Net weight of dry concentrates after sampling .. .	1,385 "
Analysis—WO <sub>3</sub> .. . . .	65.70 per cent.
Au.. . . .	2.40 oz. per ton.
Content — WO <sub>3</sub> .. . . .	909.94 pounds.
Au.. . . .	1.66 oz.

The concentrates were crushed and screened on 35 mesh until only metallics were left as the oversize. These metallics were treated to recover the bullion in them, and the undersize was weighed and sampled for analysis.

Weight after screening.. . . .	1,380 pounds.
Analysis—WO <sub>3</sub> .. . . .	65.90 per cent.
Au.. . . .	1.10 oz. per ton
Content — WO <sub>3</sub> .. . . .	909.42 pounds.
Au.. . . .	0.759 oz.
Bullion recovered by screening.. . . .	1.220 "

The material, which had been crushed to pass 35 mesh, was put through an amalgamator and then over amalgamation plates, the flow from the plates being led to a long series of settling boxes so that the scheelite would settle out from the water used in the amalgamation. After the run, all the amalgam was collected from the plates and amalgamator and treated to recover the bullion in it. The scheelite in the settling boxes was also collected, dried, weighed and sampled.

Weight after amalgamation.. . . .	1,318 pounds.
Analysis—WO <sub>3</sub> .. . . .	67.10 per cent.
Au.. . . .	0.05 oz. per ton.
Content — WO <sub>3</sub> .. . . .	884.38 pounds.
Au.. . . .	0.033 oz.
Bullion recovered by amalgamation.. . . .	0.729 "

Figuring on the contents of the different products, we have the following percentages:—

<i>Crushing and Screening—</i>	
Loss of scheelite values.. . . .	0.66 per cent.
Recovery of gold values, in metallics.. . . .	54.3 "
<i>Amalgamation—</i>	
Loss of scheelite values.. . . .	2.75 per cent.
Recovery of gold values, in amalgam.. . . .	43.7 "
<i>Summary—</i>	
Total loss of scheelite values.. . . .	2.81 per cent.
Total recovery of gold values.. . . .	98.0 "
Bullion recovered in metallics by screening.. . . .	1.220 oz.
Bullion recovered in amalgam.. . . .	0.729 "
Total bullion recovered.. . . .	1.949 "



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*Conclusions.*—

1. The value of the gold recovered from a ton of concentrates would be \$48.62, and the value of the scheelite (figured at \$15 a unit of tungsten trioxide) lost in treating a ton of concentrates would be \$24.73, so that there is a balance of \$23.89.

2. The scheelite loss would be cut down by the use of better methods to dewater and collect the scheelite after amalgamation.

3. The 98 per cent recovery of the gold values is very good. This shows that the gold is very adaptable to amalgamation.

Ottawa, April 28, 1919.

## Test No. 113.

A carload of graphite ore, weighing 60,272 pounds, was received January 27, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from Robt. Bryce, Toronto, Ont. The ore was from Low township, Quebec, and consisted of flake graphite in a gangue of quartz, calcite, and feldspar.

The shipment, as received, was made up of three lots of different grades, and hand picking, tabling and flotation tests were desired on these lots for the separation of the graphite from the gangue minerals.

*Lot No. 1 (high grade)*—

Net weight.....	119 pounds
Moisture at 3.31% .....	.119
Dry weight.....	118 pounds
Analysis—C.....	18.18 per cent
Content — C.....	12.22 pounds

*Lot No. 2 (medium grade)*—

Net weight.....	8,792 pounds
Moisture at 3.67%.....	297
Dry weight.....	7,795 pounds
Analysis.....	18.18 per cent
Content — C.....	1,411.89 pounds

*Lot No. 3 (low grade)*—

Net weight.....	48,874 pounds
Moisture at 1.554%.....	760
Dry weight.....	48,114 pounds
Analysis—C.....	4.12 per cent
Content — C.....	2,000.92 pounds

Lot No. 1 was crushed in a breaker and rolls to 1 inch and screened on  $\frac{1}{2}$ -inch and  $\frac{1}{4}$ -inch. The oversize from the screening was hand-picked. The discard from the picking and the  $\frac{1}{4}$ -inch size was crushed to pass  $\frac{1}{2}$ -inch and added in with the first  $\frac{1}{2}$ -inch size, and the whole lot tabled on a Willey table, oil being mixed with the ore before being fed to the table, and a number of air sprays being allowed to play on the surface of the table to assist the graphite flakes to rise to the surface of the water and float away. The hand-picked flake and the concentrate from the table were sampled for analysis with the following results:—

Hand-picked flake—C.....	79.20 per cent.
Concentrates from table—C.....	77.10 "

The object of the above work was to determine if a coarse flake could be produced in this manner, having a high carbon content without reducing it to a size suitable for flotation.

Lot No. 3, being the low grade ore, was treated first, the method of concentration applied being the Callow pneumatic flotation process. It was ground wet in a



Hardinge mill, using cast-iron balls for grinding. The discharge of the mill was run through a launder classifier and oversize returned to the mill, the undersize, which would be approximately 30 mesh material, was concentrated in the flotation cells. This produced a first concentrate with an analysis of 71.60 per cent carbon. Considerable difficulty was experienced in obtaining a good froth, various combinations of oil mixtures being tried to determine a suitable one for this low grade material. This resulted in a high tailing and therefore poor recovery before the proper working conditions were obtained.

Lot No. 2 and the table tailing from lot No. 1 were next run through the flotation circuit and a first concentrate obtained on this material with an analysis of approximately 80 per cent carbon. A good froth was obtained and the tailings on this higher grade material were much lower than on the low grade of lot No. 3.

The first concentrates from lot No. 3 on examination were found to include much attached graphite adhering to the gangue, so that this was re-cleaned by grinding in the Hardinge mill using pebbles and re-floating. This second concentrate approached a grade of 80 per cent carbon.

The second concentrates from lot No. 3, the first concentrate from lots Nos. 2 and 1, and the hand-picked flake together with the table concentrates from lot No. 1, were run through the circuit in order to collect the whole in one lot, and a final concentrate produced which was dried, sized in a Keedy sizer, and the weights and analyses determined as follows:—

Size.	Weight.	C. %.	C. Content.
-.0410" + .0115"	683	95.05	649.19
+ .0116"	625	91.29	570.00
+ .0118"	169	89.75	151.63
+ .0068"	637	90.30	575.21
+ .0054"	611	87.40	534.01
+ .0041"	362	88.60	320.73
+ .0036"	363	87.10	316.17
+ .0026"	116	85.20	98.83
+ .0025"	452	85.05	384.43
Total	4,018	89.60	3,600.25

The recovery is 76.41 per cent and the grade of concentrate is 89.60 per cent.

Conclusions—

1. Hand-picking and tabling might be feasible from a metallurgical viewpoint in the concentration of an ore of this class. Commercially we are of the opinion they should not be resorted to.
2. In the operation of the flotation cells, poor results were obtained on lot 3, the low grade ore. This was due to a number of causes: experimental work in obtaining the oil mixture suitable, and the proper manipulation of the cells; the graphite flake did not seem to free readily from its gangue unless fine crushing was resorted to; the percentage of graphite in the ore being low, too much oil had to be used to oil the flake, the excess having a detrimental effect on the frothing action of the cells. This trouble was not experienced on the higher grade ores and a much higher recovery of graphite would have been made had the three lots been mixed, giving a feed of 7.97 per cent carbon.
3. Considerable loss can be accounted for in the handling and step treatment which had to be resorted to in conducting the test.
4. Small scale tests conducted on the ore gave remarkable results both as to grade of concentrates and recovery.



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5. The grades of concentrates given in the above table are marketable and commercial ones on which the highest price should be obtained.

6. In practice with a mill designed for the purpose, using the Callow system of flotation concentration, in which handling losses were reduced to a minimum, concentrates of the above grade should be obtained with a recovery of from 90 per cent to 95 per cent of the carbon values.

Ottawa, February 28, 1919.

## Test No. 114.

Two bags of approximately 200 pounds of magnetic fines were received on February 10, 1919, from the Poe Mining Company, Clarendon station, Ont.

These fines were from their dry separator system, and a separation test was desired on the wet Grondal magnetic separator, to be treated in the state received.

On examination, however, it was found that they contained coarse pieces of ore and considerable material coarser than 20 mesh. This coarse material could not be treated in the Grondal wet unit, so it was necessary to screen on 20 mesh and crush the oversize down so that the total material passed through this screen. A sample was then cut out for analysis, which gave the following:—

Iron, Fe..	69.40 per cent.
Silica, SiO <sub>2</sub> ..	1.39 "
Phosphorus—P..	trace.

The material through 20 mesh was separated in the wet Grondal unit in a magnetic field with a current density of 6.5 amperes  $\times$  110 volts on the rougher drum magnets and 5 amperes  $\times$  110 volts on the cleaner drum magnets. Two products were made, a magnetic concentrate from the cleaner drum and a tailing from both rougher and cleaner drums. These products were dried, weighed, and sampled, the results being as follows:—

Magnetic Concentrates..	60 pounds.
Analyses—Iron, Fe..	69.40 per cent.
Silica, SiO <sub>2</sub> ..	1.39 "
Phosphorus, P..	none.
Tailings..	78 pounds.
Analysis—Iron, Fe..	4.92 per cent.

*Summary and conclusions.*—In conducting this small test, tubs and overflow boxes were used to catch the products. On account of the large quantity of water passing through the machine and these boxes, especially with the tailings, the loss in slime overflow was very large; besides there would be the loss in handling such small quantities, so that no accurate recoveries can be calculated.

The recovery is between 80 per cent and 90 per cent of the total iron content in the form of a high grade concentrate with an analysis of Fe, 69.40 per cent; SiO<sub>2</sub>, 1.39 per cent; P, none.

Ottawa, April 3, 1919.

## Test No. 115.

A shipment of four bags, shipping weight 300 pounds, of fluorite, calcite, and barite was received on February 12, 1919, from Gavin M. Wallbridge, manager of the Wallbridge mine, Madoc, Ont. The shipment had been taken from a vein on the west half of lot 1, concession I, Madoc township, county of Hastings, Ont.



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The shipment consisted of a natural mixture of fluorite, calcite, and barite, the individual grains of mineral ranging in size from about 1½ inch to very small crystals, and a separation of the three minerals from each other was desired.

The following table shows the weighing in of the shipment:—

Gross weight.. . . .	292 lbs.
Weight of 4 bags.. . . .	5 "
Net weight.. . . .	287 "
2 specimens.. . . .	7 "
Remainder.. . . .	280 "

This remainder of 280 pounds was crushed to pass ½ inch and a combined moisture and head sample taken out for analysis. This sample gave the following results:—

Moisture.. . . .	4.00 per cent of the wet ore.
Barite (BaSO <sub>4</sub> ).. . . .	4.40 per cent of the dry ore.
Fluorite (CaF <sub>2</sub> ).. . . .	48.35 per cent of the dry ore.
Calcite (CaCO <sub>3</sub> ).. . . .	40.00 per cent of the dry ore.
Silica (SiO <sub>2</sub> ).. . . .	3.10 per cent of the dry ore.
Alumina and iron oxide.. . . .	1.60 per cent of the dry ore.

As a preliminary test, 17 pounds of the ore was dried and crushed to pass 20 mesh, and then run over the small laboratory Wilfley table. This test gave a very poor separation, due to the great range in size of the material.

The products of the above test were dried, mixed, and screened on 30, 40, and 50 mesh. This produced four sizes of material, and all these sizes were run over the small table separately. In each case, a good separation of the barite from the fluorite and calcite was effected, and a somewhat fair separation of the fluorite from the calcite.

From the results of the preliminary tests, it was decided to crush all the ore to pass 20 mesh and screen on 35 and 80, and to run each size separately over the large Wilfley table.

The main lot of ore was dried and crushed to pass 20 mesh, and the products from the preliminary tests were dried and added in. Screening on 35 and 80 mesh was then done, and each lot was sampled for analysis and weighed. The lots were then run separately over the large Wilfley table, making a barite, fluorite, and calcite product, and where it was deemed advisable these products were re-run over the table and split into a head and a tail. All the products were dried, weighed, and sampled for analysis.

The weights, analyses, and results of the final test are tabulated in the accompanying table.

Conclusions—

1. To effect a good separation and obtain good products the ore will have to be ground to about 80 mesh.
2. The slime loss in the separation of the —80 product is very heavy, due to two causes; the poor design of the boxes used to catch the products from the table, and the dry crushing to pass 20 mesh and screening on 35 and 80, all the slimes produced going either into the —80 material, or into the air as dust. With the use of a wet ball mill to grind all the ore to be separated on the table to —80 mesh less slimes would result, and nothing would be lost as dust. If tanks were used to catch and dewater the products from the table there would result a further saving, although this would be mostly in calcite, it being the mineral which shows the greatest tendency to slime.



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3. If the slime loss could be kept down to 10 per cent, then, using the data from the treatment of the —80 mesh product, there would result the following recoveries and grades of products:—

Mineral.	Recovery per cent.	Grade per cent.
Barite...	75.5	81.85
Fluorite...	65.2	74.8
Calcite...	63.7	59.20

4. On tabling the ore less material could be taken off as the fluorite product, and this would give a better grade of fluorite, but the recovery would be lowered.

5. The original ore is rather low in barite, and Mr. Wallbridge is of the opinion that the average run would be much higher. If this is so, there would result a much better grade of barite from the separation.

SEPARATION OF -20+35 PRODUCT.

Product.	Weight Lbs.	Analysis.			Content.			Percentages.		
		BaSO <sub>4</sub>	CaF <sub>2</sub>	CaCO <sub>3</sub>	BaSO <sub>4</sub>	CaF <sub>2</sub>	CaCO <sub>3</sub>	BaSO <sub>4</sub>	CaF <sub>2</sub>	CaCO <sub>3</sub>
Barite heads...	3.0	36.40	50.60	6.40	1.09	1.52	0.19			
Barite tails...	1.0	6.60	77.20	10.90	0.26	3.03	0.44			
Fluorite...	47.0	0.90	64.20	27.60	0.42	30.17	12.97			
Calcite...	34.0	0.04	27.90	60.60	0.01	9.49	20.40			
Slime loss...	0.5				0.79	1.44	0.16			
Totals	88.5	2.99	51.65	35.00	2.57	45.71	34.16			

SEPARATION OF -35+80 PRODUCT.

Barite heads...	2.0	75.10	20.00	2.36	1.50	0.40	0.05			
Barite tails...	1.5	52.25	37.20	5.08	0.78	0.56	0.08			
Fluorite...	20.5	2.61	75.10	18.50	0.53	15.40	3.79			
Calcite heads...	50.0	0.20	52.20	42.20	0.10	26.10	21.10			
Calcite tails...	17.0	0.00	16.10	73.60	0.00	2.74	12.51			
Slime loss...	0.5				0.66	0.46	0.03			
Totals	91.5	3.90	48.90	41.05	3.57	44.74	37.56			

SEPARATION OF -80 PRODUCT.

Barite	3.5	81.85	12.64	2.25	2.86	0.44	0.08	56.4	1.1	0.2
Fluorite.....	11.0	6.60	82.00	7.15	0.73	9.02	0.79	14.4	22.5	2.2
Calcite heads...	13.0	0.00	68.60	27.70	0.00	8.92	3.60	0.0	22.2	10.0
Calcite tails.....	21.0	0.00	33.90	59.29	0.00	7.12	12.43	0.0	17.7	34.7
Slime loss.....	39.0	3.79	37.59	48.64	1.48	14.66	18.97	29.2	36.5	52.9
Totals	87.5	5.80	45.90	41.00	5.07	40.16	35.87	100.0	100.0	100.0

Ottawa, March 6, 1919.

Test No. 116.

A shipment of two bags of about 120 pounds of rock carrying molybdenite was received on February 24, 1919, from G. F. Creaghan, Esq., Kent street, Ottawa. These samples were from lot No. 4, range I, Egan township, Wright county, Quebec. The molybdenite was of the flake variety, fairly small and disseminated through the rock, which was composed of quartzite and pyroxenite. Iron pyrites were also present.



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The whole shipment was crushed, and a sample prepared for analysis which gave the following:—

Molybdenite— $\text{MoS}_2$  . . . . . 0.25 per cent.

A small flotation test was made on a portion crushed to 40 mesh, the tailings from which were sampled for analysis and which gave the following:—

Molybdenite— $\text{MoS}_2$  . . . . . 0.07 per cent.

*Summary and conclusions.*—Under present conditions the above grade would not be classed as an ore. The flotation test conducted on it showed that the molybdenite could be concentrated from the gangue material very readily. The recovery, calculated from the analysis of the crude ore and tailings, is 72 per cent of the molybdenite values, which is a fair recovery on such low grade material.

Ottawa, April 17, 1919

Test No. 117.

A sample of silica rock, weighing 300 pounds (3 bags) was received March 9, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from Stinson-Reeb Builders Supply Co., Ltd., Montreal, Que.

The sample consisted of a white siliceous rock ranging in size from about 2 inches to fine dust.

A washing test was desired on this material to see if it would be possible to produce a good grade of glass sand.

The whole sample was dried and screened on 12 mesh, the oversize being crushed in rolls and screened alternately until it all passed through the screens. A sample for analysis was then cut out by means of a Jones riffle. This gave the following:—

Silica . . . . .	96.76 per cent
Alumina . . . . .	0.62 "
Ferric oxide . . . . .	0.86 "
Lime . . . . .	1.32 "
Magnesia . . . . .	0.37 "
Loss on ignition . . . . .	0.94 "

After sampling, the remainder of the material through 12 mesh, was weighed, and washed in a Richard's classifier. The washed material was dried and screened on 20-and 100 mesh screens, the three products from the screens being weighed separately. The following table shows the weights of the heads and different products of the above washing and screening test:—

Product.	Weight, Lbs.	Per cent by weight.
+ 20 mesh . . . . .	13.0	5.9
— 20 + 100 mesh . . . . .	171.5	77.8
— 100 mesh . . . . .	13.0	5.9
Washings . . . . .	23.0	10.4
	<hr/>	<hr/>
Heads . . . . .	220.5	100.0

The — 20 + 100-mesh material was sampled for analysis with the following results:—

Silica . . . . .	99.50 per cent.
Alumina . . . . .	0.06 "
Ferric oxide . . . . .	0.22 "
Lime . . . . .	0.22 "
Magnesia . . . . .	none
Loss on ignition . . . . .	0.32 "

Thinking that better results might be obtained by washing the silica rock in a more vigorous manner, six pounds of the — 20 + 100 product were washed in one-pound charges in the impeller compartment of a Janney flotation machine. Each charge was washed for twenty minutes in the machine, then withdrawn, the dis-



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coloured water poured off, and clear water added and decanted until no discolour remained. The six charges were combined, dried, weighed (5.33 pounds), and sampled for analysis. The sample gave the following:—

Silica.. . . .	99.70 per cent.
Alumina. . . . .	0.03 "
Ferric oxide.. . . .	trace
Lime.. . . .	0.12 "
Magnesia.. . . .	0.12 "
Loss on ignition.. . . .	0.18 "

Four pounds of the — 20 + 100-mesh material were put through an oil flotation process in the Janney machine in one-pound charges. Each charge was mixed with the required amount of oil in a small pebble mill for five minutes, and then treated in the flotation machine for twenty minutes, the charge being then withdrawn and the discoloured water being removed in the same manner as in the previous test. The combined four charges were dried, weighed (3.55 pounds), and sampled for analysis. The sample gave the following:—

Silica.. . . .	99.70 per cent.
Alumina. . . . .	0.04 "
Ferric oxide.. . . .	0.15 "
Lime.. . . .	trace
Magnesia.. . . .	0.05 "
Loss on ignition.. . . .	0.16 "

*Conclusions.—*

1. By the use of a log washer a product similar to that produced by washing the silica rock in the impeller compartment of a Janney machine would be obtained and this product would be a very good glass sand.

2. The analysis of the material treated by the flotation process shows ferric oxide 0.15 per cent. This is rust from the drying pans, and in reality this product would only run a trace of ferric oxide. It will be seen then that flotation leaves the alumina, ferric oxide, and loss on ignition about the same, lowers the lime and magnesia, and thereby slightly increases the silica. A slightly better grade of sand might be produced by flotation, but the extra cost of production would hardly warrant it.

3. The analyses for magnesia in the different products do not check closely. This is due to the difficulty of the determination, especially when very small amounts are present.

*Ottawa, December 27, 1919.*

**Test No. 118.**

A shipment of 1,000 pounds each of copper-nickel ore and slag was received from Sudbury, Ont. This shipment was made by the Nieu-Steel Corporation, Toronto, Ont.

Both lots were crushed to 20 mesh and sampled, giving the following analyses:—

		Ore. .	Slag.
		per cent.	per cent.
Copper.. . . .	Cu	0.60	0.27
Nickel.. . . .	Ni	3.00	0.28
Silica.. . . .	SiO <sub>2</sub>	1.00	36.25
Sulphur.. . . .	S	32.20	0.45
Sulphur triox.....	S	.....	Trace
Alumina.. . . .	Al <sub>2</sub> O <sub>3</sub>	2.10	10.05
Lime.. . . .	CaO	0.20	3.95
Magnesia.. . . .	MgO	.....	.....

The object of the test work was to produce a sinter suitable for blast furnace use for conversion into pig from which copper-nickel steel could be obtained.

The first series of tests consisted of mixing the crushed ore and slag in the proportions of 40 : 60 and 50 : 50 with varying percentages of charcoal and 7.5 per cent water, and sintering 50-pound charges of the mixture. The sinter obtained



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showed that the sulphur was reduced to 2.5 per cent; this, however, was too high. By regrinding and a second sintering the required results might be obtained.

A second series of tests were run by first roasting to about 12 per cent sulphur and then mixing the roast ore and slag in the proportion of 50 : 50 with varying percentages of charcoal and 7.5 per cent water. The sinter obtained showed the sulphur to be reduced to about 0.75 per cent.

A third series of tests were run by first roasting to about 5 per cent sulphur, and then mixing the roast ore and slag in the proportion of 50 : 50, with varying percentages of charcoal and 7.5 per cent water. The sinter obtained showed the sulphur to be reduced to about 0.5 per cent, which would be quite within the range for blast furnace use.

A fourth series of tests were run by first roasting the ore to about 0.75 per cent sulphur and then mixing as before. The sinter obtained from these tests showed the sulphur content reduced to about 0.35 per cent.

Test work is being continued on this problem, but from the work already performed it seems feasible that a good sinter, suitable for blast furnace work, can be obtained by first reducing the sulphur in the ore to about 5 per cent and then mixing with the slag in the proportion of 50 : 50, and sintering.

It is also probable that a suitable blast furnace feed can be obtained by sintering twice or thrice without roasting, after mixing the ore and slag in the proper proportions.

The actual results of the test runs will be contained in a subsequent report when the work is completed.

Ottawa, April 8, 1919.

Test No. 119.

Six small samples of scheelite were received on March 22, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from G. B. Mackenzie, gold commissioner of the Yukon territories, Dawson city. These samples had been taken from the Bum Boy and Cairnes claims, Dublin Gulch.

Four of the samples, Nos. 1, 2, 4, and 5, were of scheelite ore as mined, and the remaining two, which had lost their numbers in transit, were of scheelite panned from the original ore.

Analyses on all the six samples for tungsten trioxide ( $WO_3$ ) were desired, besides a small concentration test on the four original ore samples. It was decided also at the testing plant to assay some of the samples for gold.

Analyses—		
Sample.	$WO_3$ per cent.	Au. oz. per ton.
No. 1. . . . .	10.00	
No. 2. . . . .	20.00	
No. 4. . . . .	9.20	
No. 5. . . . .	4.30	nil.
Large panned. . . . .	63.40	nil.
Small panned. . . . .	61.30	

For the concentration test the remainders of samples Nos. 1, 2, 4, and 5, after crushing to pass 20 mesh, and the removal of a small portion for analysis, were combined and run over a small laboratory Wilfley table, making a concentrate, a middling, and a tailing. The three products were dried, weighed and sampled for analysis. The following table shows the weights, analyses and results of this test:—

Product.	Wt. gms.	Per cent.	Content, gms.	Percent-
		$WO_3$ .	$WO_3$ .	ages $WO_3$ .
Concentrate. . . . .	783	67.50	528.52	84.4
Middlings. . . . .	291	1.40	4.07	.6
Tailings. . . . .	2,603	1.70	44.25	7.1
Slime loss. . . . .	930	5.35	49.71	7.9
Heads. . . . .	4,607	13.60	626.55	100.0



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*Conclusions.*—

1. The amount of material used for this test being very small (10 pounds), and the table upon which the test was made being only a laboratory model of the standard Willey table, the results obtained cannot be considered as being at all accurate.

2. Results by treating the ore on a large table would certainly be much better both in regard to per cent recovery and grade of concentrate.

3. The test indicates that the ore should be ground finer than 20 mesh to free all the scheelite.

4. If the grinding of the ore were done in ball mills much less slime would be produced and better results would be obtained.

5. During the test it was observed that the scheelite had a decided tendency to form a white scum and float away out of the tailing box. This partially explains the heavy slime loss of 20.2 per cent by weight of ore concentrates running 5.35 per cent  $\text{WO}_3$ , and suggests the use of flotation to treat the tailings from the concentration on tables.

6. Owing to the remoteness of the region in which this scheelite ore is mined, and in which it is desired to concentrate it, it might be deemed inadvisable to bring in any heavy machinery to treat the ore, and that treating the ore in sluice boxes would give the best monetary return. Whether this is so or not depends almost entirely on the size of the ore bodies, and their scheelite content, but we think that an ore body would have to be very small in order to make it not worth while to put in at least a small installation, consisting of a crusher, ball mill, and tables.

Ottawa, May 14, 1919.

**Test No. 120.**

*(Preliminary Report.)*

A shipment of pyrite ore weighing 10 tons was received April 1, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from the Grasselli Chemical Co., Ltd., Cleveland, Ohio. The ore was from the Caldwell mine, Flower Station, Ont., and consisted of iron pyrites in a quartzitic gangue.

A concentration test was desired on this ore to produce a product running 40 per cent sulphur or over, and to obtain as high a recovery as possible.

Half of the shipment was put through a breaker, crushing to a little over 2 inches, and then through rolls set at 2 inches. A head sample was cut out by an automatic sampler and the remainder of the ore was screened on  $\frac{1}{2}$ -inch and  $\frac{3}{4}$ -inch screens, the oversize being passed to a picking belt, where it was washed by passing under a spray, and the high grade material picked out. The slime from washing the ore on the belt was collected and dried, and the discard from the belt and the  $\frac{1}{2}$ -inch size were crushed in rolls to pass  $\frac{1}{2}$  inch. All the products were then weighed, and sampled for analysis.

The discard from the belt and the  $\frac{1}{2}$ -inch and  $\frac{3}{4}$ -inch sizes were jigged separately. The tailings from jigging the  $\frac{1}{2}$ -inch size being high in the pyrite after the first jigging, they were re-run through the jig. All the concentrates and the hutch products from the jigging were dried, weighed, and sampled for analysis. The tailings were sampled wet.

The tailings from the jigging were mixed, ground in a Hardinge mill, and separated in a launder classifier into sand and slime. The slime was sampled and pumped to waste, and the sand was tabled on a Willey table. A pyrite concentrate and a tailing were made. The tailing was sampled and pumped to waste and the concentrate was dried, weighed, and sampled.

The data obtained from the above test are given in the following tables:—



PYRITE.

SCREENING AND PICKING.

Product.	Weight Lbs.	Moisture %.	Moisture Lbs.	Dry Weight Lbs	S %.	S. Lbs.	% Total S. Value.	% Total Wt.
-1".....	2193	1.08	23.7	2169.3	38.15	827.59	28.08	25.60
+1"-1 1/2".....	2775	0.31	8.6	2766.4	35.28	975.99	33.11	32.65
Picked.....	1103	0.28	3.1	1099.9	43.89	482.75	16.38	12.98
Discard.....	2453	0.83	20.4	2432.6	27.11	659.48	22.37	28.71
Slime.....	5.5	0.00	0.0	5.5	30.04	1.65	0.06	0.06
Total.....	8529.5	.....	.....	8473.7	34.78	2947.46	100.00	100.00
Head sample .....	982	0.45	4.4	977.6	36.05	.....	.....	.....
To breaker .....	9630	0.45	43.3	9586.7	36.05	.....	.....	.....

JIGGING 1 1/2" PRODUCT.

1st No. 1 conc....	.....	.....	.....	360.5	48.89	176.25	6.10	4.36
1st No. 2 conc....	.....	.....	.....	91.0	43.11	39.23	1.36	1.10
1st No. 1 hutch...	.....	.....	.....	46.0	51.14	23.52	.82	.56
1st No. 2 hutch..	.....	.....	.....	53.5	49.58	26.53	.92	.65
2nd No. 1 conc..	.....	.....	.....	168.0	50.00	84.00	2.91	2.03
2nd No. 2 conc....	.....	.....	.....	126.0	47.75	60.16	2.08	1.52
2nd No. 1 hutch...	.....	.....	.....	88.0	51.85	45.63	1.58	1.06
2nd No. 2 hutch...	.....	.....	.....	80.0	51.70	41.36	1.43	.97
Tails.....	.....	.....	.....	1685.9	27.25	459.41	15.91	20.40
Total.....	.....	.....	.....	2698.9	35.43	956.09	33.11	32.65

JIGGING PICKING BELT DISCARD.

No. 1 conc....	.....	.....	.....	294.0	49.05	144.21	4.53	3.47
No. 2 conc.....	.....	.....	.....	144.0	46.80	67.39	2.11	1.70
No. 1 hutch.....	.....	.....	.....	148.0	51.65	76.44	2.40	1.75
No. 2 hutch.....	.....	.....	.....	69.0	51.40	35.47	1.11	.81
Tails.....	.....	.....	.....	1777.6	21.90	389.29	12.22	20.98
Total.....	.....	.....	.....	2432.6	29.30	712.80	22.37	28.71



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JIGGING 1' PRODUCT.

No. 1 conc.				473.0	49.50	239.13	7.65	5.58
No. 2 conc.				270.0	44.75	120.82	3.95	3.19
No. 1 hutch.				95.5	51.71	49.37	1.61	1.13
No. 2 hutch.				335.0	51.75	173.36	5.66	3.95
Tails.				995.8	28.30	281.81	9.21	11.75
Total.				2169.3	39.62	859.49	28.08	25.60
Jig beds.				67.5	51.85			

TABLING TAILS FROM JIGGING.

Conc.	1007.0	1.84	18.5	988.5	49.85	492.77	16.28	11.78
Slimes				2493.1	23.60	588.37	19.43	29.70
Tails.				977.7	5.05	49.37	1.63	11.65
Totals.				4459.3	25.35	1130.51	37.34	53.13



PYRITE.  
SUMMARY.

Product.	Per cent by Weight.	S per cent	Per cent Wt. × per cent S.	Percent S. Value.	Per cent by Weight	S. per cent	Percent S. Value.
HAND-PICKED . . .	12.98	43.89	569.69	15.90			
1" No. 1 conc. . . .	3.58	49.50	276.21				
1" No. 2 conc. . . .	3.19	44.75	142.75				
1 1/2" 1st No. 1 conc. . .	4.36	48.89	213.16				
1 1/2" 1st No. 2 conc. . .	1.10	43.11	47.42				
1 1/2" 2nd No. 1 conc. . .	2.03	50.00	101.50				
1 1/2" 2nd No. 2 conc. . .	1.52	47.75	72.58				
Discard No. 1 conc. . .	3.47	49.05	170.20				
Discard No. 2 conc. . . . .	1.70	46.80	79.56				
CONCENTRATES. . . . .	22.95	48.08	1,102.38	50.79	46.81	47.72	62.34
1" No. 1 hutch. . . . .	1.13	51.70	58.42				
1" No. 2 hutch. . . . .	3.95	51.75	204.41				
1 1/2" 1st No. 1 hutch. . .	.56	51.14	28.64				
1 1/2" 1st No. 2 hutch. . .	.65	49.58	32.23				
1 1/2" 2nd No. 1 hutch. . .	1.06	51.85	54.96				
1 1/2" 2nd No. 2 hutch. . .	.97	51.70	50.15				
Discard No. 1 hutch. . . .	1.75	51.65	90.39				
Discard No. 2 hutch. . . . .	.81	51.40	41.63				
HUTCHES . . . . .	10.88	51.55	560.83	15.65			
1" tails. . . . .	11.75	28.20	332.52				
1 1/2" tails . . . . .	20.40	27.25	555.90				
Discard tails. . . . .	20.98	21.90	459.46		53.19	25.37	37.66
TAILS. . . . .	53.13	25.37	1,347.88	37.61			
Belt slime. . . . .	.06	30.04	1.80	0.05			
Total. . . . .	100.00	35.84	3,583.58				

Conclusions.

- 1. Figuring on the hand-picked and the jig concentrate and hutches, we have a recovery of 62.34 per cent of the sulphur values in a product 47.72 per cent sulphur.
- 2. The grade of concentrate produced is very good.
- 3. The recovery is low.
- 4. Further testing will be carried out with an endeavour to substantially increase the recovery by producing a lower grade of concentrate.
- 5. By tabling the recovery is increased by 16.28 per cent but the additional concentrate recovered is fine and hence not very desirable.

Ottawa, May 28, 1919.

Test No. 120.

(Final Report).

A shipment of pyrite ore weighing 10 tons was received April 1, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from the Grasselli Chemical Company, Limited, Cleveland, Ohio. The ore was from the Caldwell mine, Flower Station, Ont., and consisted of iron pyrites in a quartz gangue.

A concentration test was desired on this ore to produce a product running 40 per cent sulphur or over, and to obtain as high a recovery as possible.

A test was made upon one-half of the shipment, and a preliminary report, describing this test, and giving the data obtained from it, was submitted.



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In the first test, the grade of concentrate was high and the recovery low. With the idea of increasing the recovery by producing a lower grade of concentrate, the following test was made:—

One-fourth of the shipment was put through a breaker crushing to a little over 2 inches, and then through rolls set at 2 inches. A head sample was cut out by an automatic sampler, and the remainder of the ore was screened on ½-inch and 1½-inch screens, the oversize being passed to a picking belt, where it was washed by passing under a spray, and the high grade material picked out. The slime from washing the ore on the belt was collected and dried, and the discard from the belt and the 1½-inch size were crushed in rolls to pass ½-inch. The hand-picked material was weighed and sampled. The belt discard and 1½-inch size, after being reduced to ½-inch, were mixed with the slime from the picking belt, and the ½-inch size, weighed, and sampled.

The mixed product was then jigged, making 2 concentrates, 2 hutches and a tailing, all of which were dried, weighed, and sampled. The weight and assay of the slime lost in jigging were figured by difference.

The data obtained from the above test are given in the following tables:—

PYRITE.

CRUSHING, SCREENING AND PICKING.

Product.	Wet Wt. Lbs.	Moisture.		Dry Wt. Lbs.	Sulphur %	Sulphur Lbs.	Per cent Total S. value	Per cent Total Wt.
		Per cent	Lbs.					
Hand-picked. ....	979	0.13	1.3	977.7	40.75	398.41	26.60	23.30
Mixed. ....	3,242	0.70	22.7	3,219.3	34.15	1,099.39	73.40	76.70
Total.....				4,197.0	35.69	1,497.80	100.00	100.00
Head sample.....	670	0.42	2.8	667.2	35.15			
Heads .....	4,910	0.42	20.6	4,889.4	35.15			

JIGGING.

No. 1 conc ..				703.5	46.01	323.68	21.62	16.77
No. 2 conc ..				140.0	33.42	46.79	3.12	3.34
No. 1 hutch..				1,041.0	49.70	517.38	34.56	24.81
No. 2 hutch..				98.0	36.93	36.19	2.42	2.34
Tails.....				1,095.0	12.45	136.33	9.11	26.10
Slimes.....				140.3	27.45	38.51	2.57	3.34
Total . . .	3,240.5	0.70	22.7	3,217.8	34.15	1,098.88	73.40	76.70

SUMMARY.

Product.	Per cent Total S. Value.	Per cent Total Weight.	Sulphur %	Per cent Fines —20 mesh.
Hand-picked.....	26.60	23.30	40.75	0.00
No. 1 conc.....	21.62	16.77	46.01	0.00
No. 2 conc.....	3.12	3.34	33.42	0.00
No. 1 hutch.....	34.56	24.81	49.70	40.29
No. 2 hutch.....	2.42	2.34	36.93	70.40
Total conc.....	88.32	70.56	44.67	16.50
Tails.....	9.11	26.10	12.45	
Slimes.....	2.57	3.34	27.45	
Total tails.....	11.68	29.44	14.16	



Conclusions.

- 1. The grade of concentrate produced, 44.67 per cent sulphur, is good.
- 2. The recovery 88.32 per cent is very good.
- 3. The rate of concentration is as 10 is to 7.
- 4. The fines under 20 mesh are 16.50 per cent of the combined concentrates. This is rather high, but by crushing in stages, and picking and jigging the ore in slightly larger sizes, this would be kept down to 10 per cent, which would be fair.

Ottawa, July 10, 1919.

Test No. 121.

A shipment of manganese ore weighing 2,000 pounds was received April 9, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from A. A. Hassan, 120 Broadway, New York, N.Y. The ore was from the Tenecape manganese mine, Kennetcooke station, Nova Scotia, and consisted mainly of pyrolusite in a gangue of calcite.

A concentration test was desired on this ore to produce a product running 48 per cent manganese or over, and to obtain as high a recovery as possible.

The ore was in two lots, a low grade lot from the mine called lot No. 1, and a higher grade lot from the mine dumps called lot No. 2. Both lots were weighed and crushed to 1/4 inch. Lot No. 1 weighed 1,193 pounds, and lot No. 2 weighed 774 pounds. By means of a Jones sampler 66 pounds were cut out of lot No. 1 and 45 pounds out of lot No. 2, each quantity crushed to —30 mesh, and a small head sample taken out for analysis. This gave the following:—

	Lot No. 1.	Lot No. 2.
	%	%
Moisture..	2.22	2.79
Manganese..	11.73	20.34
Iron..	2.95	2.65
Silica..	3.35	3.15
Phosphorus..	.70	.025

Test No. 1.

By means of a Jones sampler, 7,117 grams of lot No. 1 and 4,871 grams of lot No. 2 were cut out of the —30 mesh material. These quantities were screened on 40 and 50 mesh making 3 sizes in each lot. All these sizes were weighed and run separately over a small Wilfley table, making a concentrate, a middling, and a tailing. These products were caught in settling boxes, and the overflow from the boxes was run to a tank where the slime was allowed to settle out. The settling boxes were cleaned after running each lot and the slime tank was cleaned only after running all the lots. All the products from the tabling were dried, weighed, and sampled. The following table gives the data obtained from this first test:—



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SMALL WILFLEY TABLE TEST.

Product.	Wt. Gms.	% Mn	Gms Mn.	% Recovery.
No. 1, -30+40 conc.....	179	24.95	44.66	30.2
No. 1, -30+40 midd.....	260	17.59	45.73	
No. 1, -30+40 tails.....	1298	3.41	44.26	
-30+40 slimes..			13.40	36.1
No. 1, -40+50 conc.....	175	34.45	60.29	
No. 1, -40+50 midd.....	180	15.59	28.06	
No. 1, -40+50 tails.....	981	4.15	40.71	
-40+50 slimes....			37.87	37.3
No. 1, -50 conc.....	548	38.39	210.38	
No. 1, -50 midd.....	200	11.43	22.86	
No. 1, -50 tails.....	1774	6.24	110.70	
-50 slimes..			220.64	55.4
No. 2, -30+40 conc.....	143	37.80	54.05	
No. 2, -30+40 midd.....	192	12.45	23.90	
No. 2, -30+40 tails.....	373	3.70	13.80	
-30+40 slimes..			5.89	61.3
No. 2, -40+50 conc.....	216	39.80	85.97	
No. 2, -40+50 midd.....	180	13.65	24.57	
No. 2, -40+50 tails.....	450	4.95	22.27	
-40+50 slimes..			7.50	52.7
No. 2, -50 conc.....	783	47.65	373.10	
No. 2, -50 midd.....	119	18.70	22.25	
No. 2, -50 tails.....	1290	9.70	125.13	
-50 slimes..			187.59	
No. 1 and No. 2 slimes.....	1322	19.52	258.05	
No. 1 and No. 2 loss.....	1325	16.21	214.84	
Totals.....	11988	15.23	1825.58	
No. 1.....	1812 gms.			
	1548 "			
	3757 "	7117	11.73	834.82
No. 2.....	741 "			
	888 "			
	3242 "	4871	20.34	990.76

Test No. 2.

A reserve portion of the ¼-inch size was cut out of each lot and the remainder of the ½-inch size and the remainder of the 30 mesh size of each lot were added together to be used in Test No. 2. This gave the following weights for the test:—

Lot No. 1.. . . . .	1,003 pounds.
Lot No. 2.. . . . .	651 "

These amounts were dried, the weights after drying being:—

Lot No. 1.. . . . .	989.5 pounds.
Lot No. 2.. . . . .	642.5 "

Each lot of ore was then ground separately in a ball mill fitted with 40 mesh screens. The weights obtained from the mill were:—

Lot No. 1.....	984 pounds.
Lot No. 2.....	628 "

Each of these lots were sampled for chemical analysis and a 4-pound sample was taken from Lot No. 1 for screen analysis. The screen analysis gave:—



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	Screen.	Wt. Cms.	%	Cumulative %
All passed.. . . . .	8			
Retained on.. . . . .	10	3	0.17	0.17
" " .. . . . .	14	6	0.34	0.51
" " .. . . . .	20	11	0.62	1.13
" " .. . . . .	28	135	7.60	8.73
" " .. . . . .	35	416	23.42	32.15
" " .. . . . .	48	200	11.26	43.41
" " .. . . . .	65	205	11.54	54.95
" " .. . . . .	100	184	10.36	65.31
" " .. . . . .	150	157	8.84	74.15
" " .. . . . .	200	130	7.32	81.47
Pass.. . . . .	200	329	18.53	
Totals.. . . . .		1,776	100.00	

Both lots were run over a large Wilfley table, making a concentrate, a middling, and a tailing. The middling was rerun, the resulting concentrate going in with the first concentrate, and the tailing with the first tailing. The overflow from the tailing settling box was pumped to a tank and the slime allowed to settle out. The tailings from each lot were separated in a launder classifier into sand and slime, the slime being run to the tank which had taken the overflow from the tailing settling box. The settling boxes were cleaned out after tabling each lot, and the slimes from each lot were allowed to collect together in the one tank. All the products except the slimes were dried. The middlings from both lots were screened on 40 mesh. The concentrates, the two sizes of middlings, and the tailings were then weighed and sampled. The concentrate from Lot No. 1 was screened on 40 mesh and the resulting sizes weighed and sampled.

The slime collected in the tank in the above operations was run onto the large Wilfley table and separated into a concentrate, a middling, and a tailing. The tailing was pumped to waste and the concentrate and middling were collected, and dried. The middling was weighed and sampled, and the concentrate was sized and each size weighed and sampled.

The following table shows the data and results obtained from this test: -

LARGE WILFLEY TABLE TEST ON LOT 1.

Product.	Weight Lbs.	Mn. %.	Mn. Lbs.	% Mn. Value.	% by Weight.
Concentrates-40... . . . .	101.5	39.10	39.686	36.10	10.57
Concentrates+40... . . . .	12.5	35.50	4.437	4.04	1.30
Middlings-40... . . . .	15.5	22.20	3.441	3.13	1.62
Middlings+40.. . . . .	499.0	3.04	14.896	13.55	51.04
Tailings.....	340.5	13.94	47.460	43.18	35.47
Slime.....					
Heads.....	960.0	11.45	109.920	100.00	100.00

LARGE WILFLEY TABLE TEST ON LOT 2.

Concentrates.....	125.5	48.55	60.930	48.39	19.98
Middlings-40.. . . . .	20.0	49.15	9.830	7.81	3.19
Middlings+40... . . . .	9.5	24.50	2.327	1.85	1.51
Tailings.....	253.0	4.80	12.144	9.64	40.29
Slimes.....	220.0	18.49	40.683	32.31	35.03
Heads.....	628.0	20.05	125.914	100.00	100.00



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LARGE WILFLEY TABLE TEST ON SLIMES LOTS 1 AND 2.

Concentrates.....	10.5	41.22	4.328	4.91	1.87
Middlings.....	32.5	36.23	11.775	13.36	5.80
Tailings and loss.....	517.5	13.92	72.040	81.73	92.33
Total.....	560.5	15.73	88.143	100.00	100.00

SCREEN TEST ON CONCENTRATES LOT 1.

Size.					
-40.....	51.5	40.35	21.991		
+40.....	45.0	38.80	17.460		
Loss.....	2.0	11.75	.235		
Total.....	101.5	39.10	39.686		

SCREEN TEST ON CONCENTRATES FROM SLIMES.

Size.	Weight Gms.	Mn. %	Mn. Gms.
+35.....	146.	34.74	50.720
+48.....	104.	34.60	35.984
+65.....	81.	32.67	26.463
+100.....	84.	34.90	29.316
+150.....	126.	40.80	51.408
+200.....	138.	46.94	64.777
-200.....	415.	46.34	192.311
	1,094.	41.22	450.979

Test No. 3.

The reserve portion consisted of:—

Lot No. 1.....	140 pounds.
Lot No. 2.....	84.5 pounds.

This reserve was used for test No. 3. The ore of each lot was dried and crushed to pass 50 mesh, and then screened on 100. The different sizes of each lot were then sampled, weighed, and run separately over the large Wilfley table, making a concentrate, middling, and a tailing. The resulting products were collected, dried, and sampled.

The following tables show the data and the results from this test, the slimes being figured out by differences:—

LARGE WILFLEY TABLE TEST ON LOT 1 -50+100.

Product.	Weight Lbs.	Mn. per cent	Mn. Lbs.	Per cent Mn. Value.	Per cent by weight.
Concentrates.....	7.0	35.85	2.51	52.2	12.4
Middlings.....	.7	13.90	.10	2.1	1.2
Tailings.....	43.0	3.58	1.54	32.0	76.1
Slimes.....	5.8	11.38	.66	13.7	10.3
Heads.....	56.5	8.51	4.81	100.0	100.0



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LARGE WILFLEY TABLE TEST ON LOT 1 -100.

Concentrates	12.5	40.60	5.07	46.4	15.7
Middlings.....	1.0	26.75	.27	2.5	1.3
Tailings..	40.0	6.45	2.58	23.6	50.3
Slimes.	26.0	11.58	3.01	27.5	32.7
Heads.	79.5	13.75	10.93	100.0	100.0

LARGE WILFLEY TABLE TEST ON LOT 2 -50+100.

Concentrates.	6.2	43.80	2.72	62.1	21.4
Middlings.	1.0	19.60	.20	4.6	3.4
Tailings..	18.5	4.25	.79	18.0	63.8
Slimes.	3.3	20.30	.67	15.3	11.4
Heads.	29.0	15.10	4.38	100.0	100.0

LARGE WILFLEY TABLE TEST ON LOT 2 -100.

Concentrates.	14.0	49.08	6.87	54.0	25.5
Middlings.	1.0	27.18	.27	2.1	1.8
Tailings..	22.5	1.05	.24	1.9	40.9
Slimes.....	17.5	30.58	5.35	42.0	31.8
Heads.	55.0	23.15	12.73	100.0	100.0

Conclusions.

- 1. The results of the tests show that the recovery of the manganese values in the ores are low. A number of manganese ores from the Maritime Provinces have been received for test purposes in carload lots and smaller lots, and in all cases gravity concentration has shown a low recovery of the manganese values.
- 2. The grade of concentrates produced on this particular ore is low and could only be used for metallurgical purposes. A small quantity of high grade concentrates suitable for chemical purposes could be cut out, but the grade of the remaining concentrate would be lowered.
- 3. Recoveries and grade of concentrates obtained depend on the grade of the ore. The higher the grade the better recovery and grade of concentrate. This holds good on all the manganese ores tested from the Maritime Provinces. There is a slight difference in some cases in the crystallization of the pyrolusite. The finer the crystallization, the finer the grinding necessary and therefore the greater loss in slimes.
- 4. High recoveries and high grade products can be obtained from manganese ores by wet chemical methods and precipitation by electrolysis, but these methods would be prohibited on low grade ores.

Ottawa, June 9, 1919.

Test No. 122.

A sample of barite weighing 10 pounds was received May 3, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from T. B. Caldwell, Lanark, Ont.

The barite contained argentiferous tetrahedrite, and a little azurite and malachite. Tests were desired on this sample to determine if it would be possible to recover the silver and copper in a concentrate, and produce a clean, high grade barite.



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The whole sample was ground to pass 100 mesh, and a sample was cut out for analysis. This sample gave the following:—

Barium sulphate	97.75 per cent.
Copper	0.52 "
Silver	1.80 oz. per ton.
Antimony	present.
Arsenic	present.

Four flotation tests were made upon the material ground to pass 100 mesh, the procedure in each test being as follows: Five hundred grams of the ore were put into a small ball mill along with the required amount of oil and enough water to make a thick pulp. The mill was then revolved for 5 minutes to mix the oil into the ore. The mixed charge was then washed into a small Janney flotation machine and agitated for 5 minutes. During the agitation the froth was skimmed off as it formed.

The oils used in the tests were as follows:—

Test 1. Pine oil. . .	0.1	c.c.	Coal tar. . . . .	0.1	c.c.	Coal tar, Creosote. . .	0.3	c.c.
" 2. Oil No. 26. . .	0.2	c.c.	" " . . . . .	0.05	c.c.	" " . . . . .	0.2	c.c.
" 3. Oil No. 27. . .	0.2	c.c.	" " . . . . .	0.05	c.c.	" " . . . . .	0.2	c.c.
" 4. Oil No. 29. . .	0.125	c.c.	" " . . . . .	0.05	c.c.	" " . . . . .	0.3	c.c.

Test No. 1 gave a good amount of fair froth, and tests Nos. 2, 3, and 4 gave a good amount of slightly gummy froth.

The results obtained from the four tests are given in the following table:—

## BARITE AND TETRAHEDRITE.

Product	Weight. Gms.	Per cent Cu.	Oz. Ag.	Cu. Gms.	Wt. Gms. × Ozs. Ag.	Per cent Cu. Value.	Per cent Ag. Value.
No. 1 concentrates	33.6	6.05	10.92	2.033	366.9	78.2	40.8
No. 1 tails	466.4	0.11	1.14	0.513	531.7		
No. 1 heads	500.0	0.51	1.80	2.546	898.6		
No. 2 concentrates	60.2	3.40	6.02	2.047	362.4	78.7	40.3
No. 2 tails	439.8	0.09	0.19	0.396	83.6		
No. 2 heads	500.0	0.49	0.89	2.443	446.0		
No. 3 concentrates	44.1	4.50	10.12	1.984	446.3	76.3	49.6
No. 3 tails	455.9	0.07	0.05	0.319	22.8		
No. 3 heads	500.0	0.46	0.94	2.303	469.1		
No. 4 concentrates	32.0	5.80	14.08	1.856	450.6	71.4	50.1
No. 4 tails	468.0	0.07	0.20	0.328	93.6		
No. 4 heads	500.0	0.44	1.09	2.184	544.2		
Heads	500.0	0.52	1.80	2.600	900.0		

The tailings from Test No. 3 were assayed and found to be 97.75 per cent barium sulphate.

*Conclusions.*

1. The grade of barite produced is very good as shown by the tails of test No. 3. These tails are clean and white, and run 97.75 per cent barium sulphate.
2. The recovery of the copper is fair, approximately 80 per cent.
3. The recovery of the silver is fairly low, approximately 50 per cent.
4. The work conducted on this sample was only of a preliminary nature, and although the results are encouraging, the sample was too small and was used up before any final results could be determined.



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Ottawa, December 31, 1919.

Test No. 123.

Two samples of euxenite ore, weighing respectively 22 and 74 pounds, were received at the Ore Dressing and Metallurgical Laboratories on June 19, 1919. These samples were sent in by the Geological Survey, and had come from Maberley, Sherbrooke township, Ontario.

The samples consisted of fairly large crystalline pieces of euxenite in a gangue of very good orthoclase feldspar.

It was desired to conduct tests to see if it would be possible to recover the euxenite in a high grade concentrate, and at the same time, produce a clean, marketable feldspar.

Each sample was crushed separately to pass 4 mesh, and then screened on 6, 8, 10, 14, and 20. The sizes coarser than 20 were treated separately on a small Richards jig, making a concentrate and tailing out of each size. The concentrates were combined and the tailings were combined, dried, and put with the -20 mesh material. This mixture was then crushed to pass 30 mesh and screened on 80. The two sizes —30+80 and —80 were then tabled separately on a small Willey table. The concentrates from the table were put with the jig concentrates, and the table tailings were combined. This gave one concentrate and one tailing for each lot, and these were dried and weighed.

Lot 1 (high grade)—

Heads used in test.. . . .	20 lb. 5 oz.
Concentrates.. . . .	10 lb. 11 oz.
Tailings.. . . .	8 lb. 8 oz.

Lot 2 (low grade)—

Heads used in test.. . . .	68 lb. 9 oz.
Concentrates.. . . .	5 lb. 8 oz.
Tailings.. . . .	53 lb. 14 oz.

The concentrate produced from each sample was fairly high grade and the tailing was very clean in each case. These products were sent to the Geological Survey.

Ottawa, December 31, 1919.

Test No. 124.

A shipment of one bag of scheelite concentrates was received on July 7, 1919, at the testing plant of the Ore Dressing and Metallurgical Division, from Wm. Steinberger, Esq., Dawson City, Yukon Territory.

The concentrates were shipped from Skagway and had been produced by placer mining. They contained, besides the scheelite, a certain amount of gold, this being in the form of metallic flakes of fair size.

A mill test was desired to ascertain if the gold could be recovered from the scheelite concentrates by an economical process.

Gross weight of concentrates.. . . .	150 pounds
Net weight of concentrates.. . . .	146.25 "

The concentrates were crushed and screened on 35 mesh until only metallies were left as oversize. The metallies were treated to recover the bullion in them, and the undersize was weighed and sampled for analysis.

Weight after screening.. . . .	144.5 pounds.
Weight of sample.. . . .	0.5 "
Net weight after sampling.. . . .	144 "
Analysis—WO <sub>3</sub> .. . . .	64.30 per cent.
Au.. . . .	3.87 oz. per ton.
Content — WO <sub>3</sub> .. . . .	92.59 pounds.
Au.. . . .	0.2786 oz.
Bullion recovered by screening.. . . .	0.2166 "



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The material which had been crushed to pass 35 mesh was put through an amalgamator and then over amalgamation plates, the flow from the plates being led to a long series of settling boxes so that the scheelite would settle out from the water used in amalgamation. After the run, all the amalgam was collected from the plates and amalgamator, and was treated to recover the bullion in it. The scheelite in the settling boxes was also collected, dried, weighed, and sampled.

Weight after amalgamation.. . . .	139.25 pounds.
Analysis—WO <sub>3</sub> .. . . .	64.50 per cent.
Au.. . . .	0.06 oz. per ton.
Content—WO <sub>3</sub> .. . . .	89.82 pounds.
Au.. . . .	0.0042 oz.
Bullion recovered by amalgamation.. . . .	0.2890 "

Figuring on the contents of the different products, we have the following percentages:—

<i>Crushing and Screening—</i>	
Recovery of gold values in metallics.. . . .	42.4 per cent.
Loss of scheelite values would be about.. . . .	0.06 "
<i>Amalgamation—</i>	
Recovery of gold values in amalgam.. . . .	56.7 per cent.
Loss of scheelite values.. . . .	2.99 "
<i>Screening—</i>	
Total recovery of gold values.. . . .	99.1 per cent.
Total loss of scheelite values.. . . .	3.05 "
Bullion recovered in metallics by screening. . .	0.2166 oz.
Bullion recovered in amalgam.. . . .	0.2890 "
Total bullion recovered.. . . .	0.5056 "

*Conclusions.—*

1. The value of the gold recovered from a ton of concentrates would be \$136, and the value of the scheelite (figured at \$8 a unit of tungsten trioxide) lost in treating a ton of concentrate would be \$14, so that there is a balance of \$122.

2. The scheelite loss would be cut down by the use of better methods to dewater and collect the scheelite after amalgamation.

3. The 99.1 per cent recovery of the gold values is very good. This shows that the gold is very adaptable to amalgamation.

Ottawa, October 22, 1919.

## Test No. 125.

A shipment of twenty-five sacks of about 1,000 pounds of low grade molybdenite ore was received on August 8, 1919, from J. H. Teare, Esq., Sault Ste. Marie, Ont. This shipment of ore had been mined at Harvey, Ont.

The molybdenite was of the flake variety, fairly small and disseminated through a gangue which consisted of quartz and green hornblende; and carried small amounts of pyrite, mica, and white feldspar.

The shipment was divided into three lots, called as follows:—

Lot XXX.

Hanging-wall lot.

Foot-wall lot.

All the three lots were crushed separately to pass 40 mesh, and sampled. The samples upon analysis gave the following results:—

<i>Lot XXX—</i>	
MoS <sub>2</sub> .. . . .	0.40 per cent.
Ag.. . . .	trace.
Au.. . . .	none.
<i>Hanging-wall lot—</i>	
MoS <sub>2</sub> .. . . .	0.43 per cent.
Ag.. . . .	none.
Au.. . . .	none.
<i>Foot-wall lot—</i>	
MoS <sub>2</sub> .. . . .	0.16 per cent.
Ag.. . . .	none.
Au.. . . .	none.



Two small flotation tests were made upon a portion of Lot XXX ground to pass 40 mesh. The concentrates and tailings of each test were sampled and assayed with the following results:—

Test 1—	
Concentrates.. . . . .	80.17% MoS <sub>2</sub>
Tailings.. . . . .	0.12% "
Test 2—	
Concentrates.. . . . .	91.65% MoS <sub>2</sub>
Tailings.. . . . .	0.17% "

Summary and Conclusions.—

- 1. A high grade concentrate (80 to 90 per cent MoS<sub>2</sub>) can be produced.
- 2. The recovery is fair on such low grade material (70 per cent in test 1). With finer grinding, the recovery would likely be raised to nearly 80 per cent.

REPORT ON GRAPHITE ORE FROM THE QUEBEC GRAPHITE COMPANY,  
BUCKINGHAM, QUE.

Ottawa, December 30, 1919.

Test No. 126.

A carload shipment of graphite ore was received on October 4, 1919, from the Quebec Graphite Company, Buckingham, Que.

Examination of specimens selected from this carload showed that the graphite occurs as disseminated flake, from a tenth of an inch in diameter down to the finest grains. The associated minerals are iron pyrite, mica, calcite, pyroxene, and other silicates. The graphite is intimately interfoliated with the gangue minerals, making purification difficult without destroying the size of the flake. This point was determined by selecting a flake larger than 28 mesh, which from microscopic examination would be declared pure graphite, but upon analysis was found to contain: graphitic carbon 92.25 per cent; iron and alumina 3.60 per cent; insoluble residue 3.00 per cent; volatile 1.15 per cent. This clearly demonstrated that the above analysis was the upward limit that could be obtained by any mechanical operation, without destroying the flake.

The object of the tests was to determine a suitable flow sheet adaptable to this ore using oil flotation, and if necessary, as much of the old equipment as possible, such as tables and classifiers, to make a high grade product.

Different combinations were tried to arrive at the best possible flow sheet, and for this purpose the carload was divided into approximately three-ton lots, the weight, analysis, and content of which were as follows:—

Test No.	Net weight of ore.	Assay.	Pounds carbon.
1.. . . . .	5,673.5	13.40%	760.25
2.. . . . .	5,785.5	13.40%	775.25
3.. . . . .	5,761.0	13.45%	773.85
4.. . . . .	5,738.0	13.85%	794.71
5.. . . . .	5,694.0	13.25%	754.45
6.. . . . .	8,309.0	13.10%	1,088.47
Total. . . . .	36,961.0 Or 18.48 tons.	13.34%	4,947.00

In each of the six test runs the ore, after being previously crushed in a jaw crusher to about road metal size, was weighed and sampled automatically and stored in a bin. From the bin it was automatically fed into a 4-foot Hardinge ball mill with a charge of 2,000 pounds of balls, at an approximate rate of 1,200 pounds of ore per



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hour, water being added in the ball mill and also the desired amount of oil, which was fed at varying rates in the different runs of from 1.7 pounds to 2.9 pounds per ton of ore treated.

The ground material discharged from the ball mill in the form of a pulp was elevated by means of a centrifugal pump to a Callow screen, the material which passed through the screen was fed to the Callow cells, the oversize material which would not pass through the screen being returned to the ball mill for further reduction.

The density of the pulp going to the rougher flotation cells varied from  $3\frac{1}{2}$  to  $5\frac{1}{2}$  parts by weight of water to 1 part of ore, and sometimes even more dilute when an excess of wash water was used, but in the mill this should be more easily controlled.

*Test 1.*—The ore was ground in the ball mill until it all passed a 35 by 12 Greening ton cap screen (smallest opening .015").

Average amount of oil used per ton of ore treated 2.9 pounds of mixture, containing 40 per cent No. 5 pine oil, 40 per cent No. 26 F.P.L. and 20 per cent coal oil.

It was then floated in Callow roughing cells, a low grade concentrate being made, and a very low tailing. These concentrates were ground in a Hardinge ball mill using pebbles instead of balls (the charge being 1,223 pounds of pebbles) and refloated in Callow cells, but although this material passed through four retreatment cells the grade was not sufficiently enriched by this particular method of treatment.

*Test 2.*—The ore was ground in the ball mill until it all passed a 24 by 8 Greening ton cap screen (smallest opening .02").

Average amount of oil used per ton of ore treated, 2.2 pounds of mixture containing 70 per cent No. 26 F.P.L. and 30 per cent pine oil.

It was then floated in Callow roughing cells, aiming to make a cleaner concentrate than in test 1 by allowing a little more graphite to go off in the tailings. But the results are not of sufficient interest to more than refer to in passing, as the treatment followed would not give the desired results. But several points were disclosed which assisted in the subsequent tests. For one thing it was found that the grinding effect in the pebble mill was very slight, and in the case of the fine concentrate it was almost negative, consequently it was decided that the balls would be used instead of pebbles for regrinding the concentrate, and the feed to the ball mill would be thickened by using a settling tank in order to assist the grinding.

*Test 3.*—The ore was ground in the ball mill until it all passed a 24 by 8 Greening ton cap screen (smallest opening .02").

Average amount of oil used per ton of ore treated 2.9 pounds of No. 26 F.P.L.

It was then floated in Callow roughing cells, making a concentrate assaying 34.1 per cent carbon and a tailing which represents a recovery in this initial operation of over 90 per cent of the total carbon contents.

The concentrate was passed over a 60 by 20 Greening ton cap screen (smallest opening .009") and the oversize was concentrated on a Wilfley table, while the undersize was ground in the pebble mill and refloated in Callow cells.

This test demonstrated that by screening the rougher flotation concentrates on 60 mesh and tabling the oversize, a concentrate of about 80 per cent carbon was made, and the separation of this material on the table was better than the previous attempts when using the cells.

It was also found that refloating the undersize (—60 mesh material) only gave a concentrate assaying 57.4 per cent, and by tabling the tailings of this operation a good separation was made giving a —80 mesh concentrate assaying 81.4 per cent carbon.

This information led us to extend the use of the tables at suitable stages.

A probable reason why the tables make a better separation and a higher grade product on this concentrated material than the cells may be that the rougher concentrates consist partly of particles of almost clean flake and partly of particles com-



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posed of graphite and gangue attached, and on the tables these attached particles of gangue and graphite, having a slightly greater specific gravity than graphite itself, travel to the head of the table, while pieces of graphite being more buoyant float off the side. This action is probably augmented by the fact that the small amount of oiling tends to increase the buoyancy of the clean graphite flakes, while its effect is not shown much on the combined particles of graphite and gangue when travelling over the deck of the table.

On the other hand, apparently these attached particles, oiled and floated in the first instance, do not escape the buoyancy of the bubbles in the second flotation cells, and consequently tend to float over with the clean graphite.

*Test 4.*—The ore was ground in the ball mill until it all passed a 24 by 8 Greening ton cap screen (smallest opening .02").

Average amount of oil used per ton of ore treated, 1.8 pounds of No. 25 F.P.L.

It was then floated in Callow roughing cells (adjusted as counter current cells), the aim being to make a higher grade concentrate than previously obtained, using less oil, with the idea that the attached particles would not float in the final flotation process. But with this arrangement too much graphite was lost in the rougher tailings without sufficiently enriching the grade of concentrates, and the idea was abandoned.

Another new departure was tried in this test, namely, to screen the -60 mesh material over an 80 by 36 Greening ton cap screen (.008") after being reground in the ball mill, and to table the -60 +80 material, and it was found that a considerable portion of the graphite contents were recovered in this way in the form of a high grade concentrate assaying over 80 per cent carbon.

From the information gained in this test, it was agreed to modify the flow sheet of the mill accordingly, and in this way it is expected to recover a satisfactory proportion of the total graphite in the form of a No. 1 flake assaying over 80 per cent carbon, by tabling the +60 rougher concentrates, and also the +80 portion of the -60 rougher concentrate after they have been reground in the ball mill.

*Test 5.*—The ore was ground in the ball mill and screened on a 35 by 12 Greening ton cap screen (.015").

Average amount of oil used per ton of ore treated, 1.7 pounds of mixture, 80 per cent coal oil and 20 per cent pine oil.

The material which passed through the screen was floated in Callow roughing cells, making a concentrate of 43.20 per cent carbon and a tailing of 1.85 per cent carbon. The material which remained on the screen was screened through a coarser screen (24 by 8 Greening ton cap) and the oversize, which in practice would be returned to the ball mill to be reground, was dried and weighed, while the undersize was tabled, producing a low grade concentrate of 53.15 per cent carbon.

In this test a settling tank was provided to dewater the -80 rougher concentrate before entering the ball mill in order to permit of a better grinding effect, and a considerable reduction in the size of the material leaving the ball mill was in this way obtained. As already stated, once the No. 1 flake has been removed, this grinding is necessary in order to liberate the attached particles of graphite and gangue.

*Test 6.*—The ore was ground in the ball mill until it all passed a 24 by 8 Greening ton cap screen (.02").

Average amount of oil used per ton of ore treated, 2 pounds of mixture, 50 per cent coal oil and 50 per cent pine oil.

It was then floated in one Callow roughing cell, making a concentrate assaying 31. per cent carbon and a tailing, 0.76 per cent carbon, representing a recovery in this initial operation of 96 per cent of the total carbon contents.

The concentrate was passed over a 60 by 20 Greening ton cap screen and the oversize concentrated on a Wilfley table, producing a concentrate assaying 80.4 per



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cent carbon, and the undersize was ground in the ball mill and screened on an 80 by 36 Greening ton cap screen (.008") and then tailed, producing a concentrate assaying 82.6 per cent carbon. These two concentrates represent 29.1 per cent of the total carbon in the ore. It is interesting to note that using one rougher cell instead of two, as in the other tests, apparently made no difference in the satisfactory results of the tabling.

The -80 material was floated in Callow cells, making a concentrate assaying 57.5 per cent carbon. The tailing from the Callow cleaner cells assayed 36.1 per cent carbon, and was enriched up to 70.9 per cent carbon by tabling.

The procedure followed in this test was considered the most applicable to this particular ore, so the results are given in detail, with a flow sheet showing the procedure and arrangement.

The following table gives details of the products of test 6 with their respective weights, assays, and contents of carbon:—

Product	Weight lb.	Per cent carbon.	Lb. carbon.	Per cent total carbon.
(a) Table conc. . . . . +60	182.0	80.40	152.0	14.0
(b) Table tails. . . . . +60	394.0	12.30	48.5	4.5
(c) Callow conc. . . . . —80	514.5	57.50	295.8	27.1
(d) Rougher tails. . . . . —80	530.0	2.75	14.6	1.3
(e) Table conc. . . . . +80	198.5	82.60	164.0	15.1
(f) Table tails. . . . . +80	243.5	9.35	22.8	2.1
(g) Table conc. . . . . —80	274.0	70.90	194.3	17.8
(h) Table tails. . . . . —80	363.5	6.00	21.8	2.0
(i) Callow tails. . . . . —24	1,963.0	0.76	37.7	3.5
(j) Slime and other loss, etc.	639.0	21.44	137.0	12.6
(k) Heads. . . . .	8,309.0	13.10	1,088.5	100.0

By rearranging the results we get the following:—

## +80 Products —

(a) No. 1 flake recovered assaying 80.40% C., representing	14.0%	of total carbon.
(e) No. 1 flake recovered assaying 82.60% C., representing	15.1%	of total carbon.
(b) Table tailings which in practice will be returned to the ball mill for retreatment. . . . . 12.30% C., representing	4.5%	of total carbon.
(f) Table tailings which in practice will be returned to the ball mill for retreatment. . . . . 9.35% C., representing	2.1%	of total carbon.
	<u>35.7%</u>	<u>35.7%</u>

of which 29.1 per cent was actually recovered. In practice most of the balance (6.6) per cent would be also recovered, but probably not all as +80 material.

## -80 Products —

(c) Flotation conc. assaying 57.50%, representing. . . . .	27.1%	
of total carbon.		
(g) Table conc. assaying 70.90%, representing. . . . .	17.8%	
of total carbon.		
(h) Table tailings assaying 6.00%, representing. . . . .	2.0%	
of total carbon.		
	<u>46.9%</u>	<u>46.9%</u>
		<u>82.6%</u>

of which 44.9 per cent was actually recovered, and in practice most of the balance (2.0) would be also recovered.

Actual tailings to waste assaying 0.76%, representing. . . . .	3.5%	
of total carbon.		
Actual tailings to waste assaying 2.75%, representing. . . . .	1.3%	
of total carbon.		
	<u>4.8%</u>	<u>4.8%</u>
		<u>87.4%</u>
Loss in slimes, etc. . . . .		<u>12.6%</u>
		<u>100.0%</u>



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This 12.6 per cent loss is due to overflows and accidental losses always more or less in evidence when handling small quantities in intermittent runs, but these will not occur during regular mill operations.

While the exact figures of the recovery that will be obtained cannot be given, owing to necessary difference between a test run and regular mill operations, the above figures show that a high recovery should be attained, giving the proportion of +80 flake assaying 80 per cent carbon or better as about one-third of the total carbon content.

The actual recovery of the +80 was 29.1 per cent of the total carbon contents.  
The actual recovery of the —80 was 44.9 per cent of the total carbon contents.

74.0 per cent.

The total loss in tailings was only 4.8 per cent, which would represent a recovery of 95.2 per cent, assuming that the whole of the retreatment products were recovered and there was no slime loss. But as milling is always accompanied by some accidental losses and occasional bad operating conditions from time to time, a recovery of 95 per cent (as represented by the tailings losses in this test) should not be expected.

On the other hand it is only fair to expect that when the plant is adjusted, a considerably higher recovery will be made than that actually obtained when making a test run of only four tons, with all the disadvantages of intermittent running, and its attendant losses. So by striking the average between the two figures 74 per cent and 95 per cent, namely 85 per cent, a conservative estimate of the recovery should be arrived at, although it is quite likely that a 90 per cent recovery will ultimately be made.

A conservative estimate, based on this test, of the proportion of No. 1 flake (+80) recovered in practice can be taken as one-third of the total carbon contents, but by adjusting the milling conditions, it is possible that this percentage can be increased by coarser screening of the flotation feed to the rougher cell. In this connexion a sample of the rougher cell concentrate and tailings were screened through Tyler standard screens with the following results:—

	Conc. by wt.	Tailings by wt.
	%	%
Remaining on 35 sq. mesh screen (.0164" opening)...	5.8	3.5
Remaining on 65 sq. mesh screen (.0082" opening)...	18.9	13.2
Remaining on 150 sq. mesh screen (.0041" opening)...	27.5	23.7
Passing through 150 sq. mesh screen... . . . .	47.8	59.6
	100.0	100.0

In practice it is expected that the feed can be delivered to the rougher cell with a larger percentage of +65 mesh material than indicated by the above screen analysis, without any detrimental effect and the coarser this feed can be kept within certain limits the greater will be the proportion of No. 1 flake recovered.

This test does not include the final finishing of the flake for the market. It is understood that the Company has already this equipment and are in a position to undertake this work themselves.

Ottawa, December 10, 1919.

Test No. 127.

A shipment of sixty-eight pounds of gold ore was received on October 21, 1919, from M. R. Blake, Esq., Winnipeg, Man.

The ore consisted of white vein quartz, carrying small amounts of arsenopyrite, chalcopyrite, and galena. No free gold was visible in the original ore, but upon crushing and grinding, a large number of very fine flat flakes appeared.



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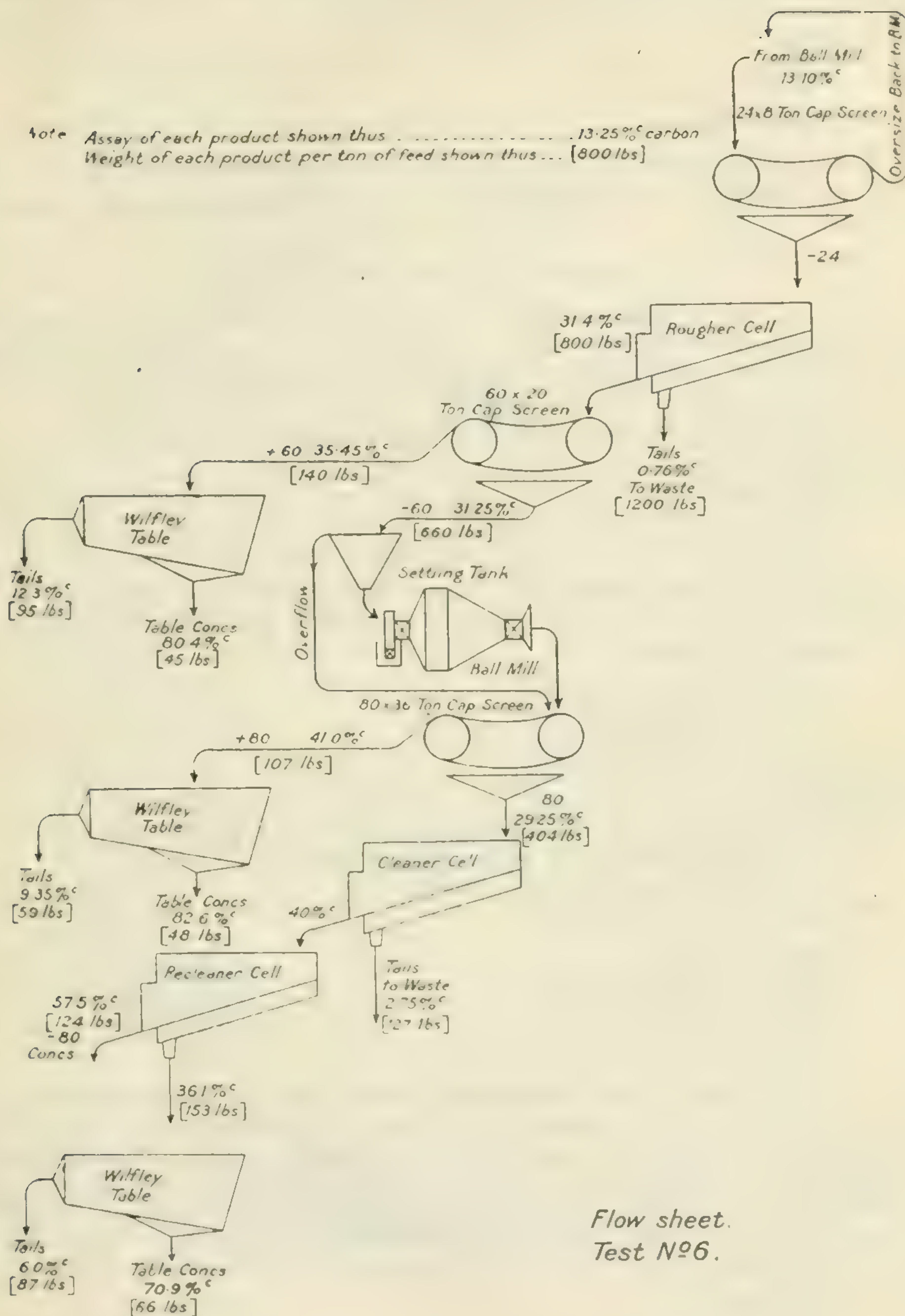


Fig. 1. Flow sheet of test No. 6: showing oil flotation process in the purification of disseminated flake graphite ore.



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A few specimens were selected from the shipment and the remaining ore was crushed to 40 mesh and duplicate samples taken, from which the following average assay was obtained:—

Gold.. . . . .	6.75 oz. per ton.
Silver.. . . . .	1.04 " "
Copper.. . . . .	0.07 per cent.
Lead.. . . . .	0.03 "
Arsenic.. . . . .	0.66 "

It was desired that a suitable process for the recovery of the gold and silver in this ore be developed, and with this end in view, the following experiments were carried out:—

AMALGAMATION AND CYANIDATION.

*Test 1.*—One thousand grams of the original ore ground to pass 40 mesh were put into a small pebble mill along with 100 grams of mercury and 400 c.c. of water. The jar was then revolved with this charge for 2½ hours, after which the contents of the jar were panned to recover the mercury. During the panning, a lot of sulphides floated away with the tails, but a small amount was saved as a concentrate.

Mercury recovered.. . . . .	100 gms.
Concentrates.. . . . .	5.2433 gms., Au 29.05 oz. per ton.
Tails.. . . . .	994 gms, Au 3.96 oz. per ton.

The tails from this amalgamation were ground to 100 mesh, and cyanided for 8 hours in a .23 per cent solution. After this treatment, the tails were sampled and cyanided again, as before.

Tails after 1st cyanidation—Au.. . . . .	0.16 oz per ton.
Tails after 2nd cyanidation—Au.. . . . .	0.06 " "
Recovery—1. In concentrates.. . . . .	2.3 per cent.
2. By amalgamation.. . . . .	39.0 "
3. By cyanidation.. . . . .	57.8 "
Loss.. . . . .	0.9 "

*Test 2.*—This test is the same as test No. 1 with the following changes:—

- 1. Charge revolved in the pebble mill 3½ hours.
- 2. No concentrate saved in panning.

This test gave the following:—

Mercury recovered.. . . . .	99.5 gms.
Tails from amalgamation.. . . . .	992 gms, Au 0.65 oz. per ton.
Tails after 1st cyanidation—Au.. . . . .	0.04 oz. per ton.
Tails after 2nd cyanidation—Au.. . . . .	trace.
Recovery—1. By amalgamation.. . . . .	91.7 per cent.
2. By cyanidation.. . . . .	8.3 "

*Test 3.*—Twenty-six and one-quarter pounds of the original ore crushed to 40 mesh were put through an amalgamator, and then over amalgamation plates, the flow from the plates being led to a series of settling boxes, so that the amalgamated ore would settle out from the water. After the run, all the amalgam was collected from the amalgamator and the plates, and treated to recover the bullion in it. The ore in the settling boxes was also collected, dried, weighed, and sampled. In panning the mercury from the ore remaining in the amalgamator, a small amount of concentrate was recovered.

Weight of tails.. . . . .	26.25 pounds.
Analysis—Au.. . . . .	1.80 oz. per ton.
Content.. . . . .	0.02362 oz.
Gold recovered in concentrate.. . . . .	0.00189 "
Gold recovered as bullion.. . . . .	0.06574 "
Gold in heads used.. . . . .	0.08859 "



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Two thousand three hundred and sixty-five grams of tailings from the above were crushed to pass 100 mesh. In doing this, a small amount of metallics was recovered on the screen. The material —100 mesh was cut in two on a Jones riffler, and the two halves were cyanided separately for eight hours in a 0.23 per cent solution, then decanted, washed, and cyanided again for eight hours with fresh solution.

First half—	
Tailings after 2nd cyanidation—Au.. .. .	0.18 oz. per ton.
Second half—	
Tailings after 2nd cyanidation—Au.. .. .	0.15 oz. per ton.

Gold recovered in metallics 32 mgs. Au 0.395 oz. per ton.

Recovery—1. By cyanidation.. .. .	2.1 per cent.
2. By amalgamation.. .. .	72.0 "
3. In metallics.. .. .	5.7 "
4. By cyanidation.. .. .	17.8 "
Loss.. .. .	2.4 "

AMALGAMATION, TABLING, AND CYANIDATION.

Test 4.—20.5 pounds of amalgamation tails from test No. 3 were tabled upon a small Wilfley table, making a concentrate, a middling and a tailing. The middlings were rerun, making a concentrate and a tailing which were put respectively with the first concentrate and tailing. In tabling, a small amount of the concentrate floated off as a scum into the tailing box; this scum was removed and put with the concentrate.

Weight of concentrate.. .. .	0.386 pound.
Analysis—Au.. .. .	82.12 oz. per ton.
Content—Au.. .. .	0.01585 oz. per ton.
Weight of tailings.. .. .	19 pounds.
Analysis—Au.. .. .	0.28 oz. per ton.
Content—Au.. .. .	0.00266 oz.
Gold in feed used.. .. .	0.01845 "

Two 1,000-gram lots of the above tailing, crushed to pass 100 mesh, were cyanided for 8 hours in a 0.23 per cent solution and then decanted, washed, and cyanided for another 8 hours with fresh solution.

Tails after 2nd cyanidation—Au.. .. .	
First lot—	0.10 oz. per ton.
Tails after 2nd cyanidation—Au.. .. .	
Second lot—	0.08 oz. per ton.
Recovery—	
1. By concentration.. .. .	2.1 per cent.
2. By amalgamation.. .. .	72.0 "
3. By tabling.. .. .	22.2 "
4. By cyanidation.. .. .	2.5 "
Loss.. .. .	1.2 "

TABLING AND CYANIDATION.

Test 5.—11.75 pounds of original ore crushed to pass 40 mesh were tabled on a small Wilfley table, making a concentrate, a middling, and a tailing. The middling was rerun, making a concentrate and a tailing, which were put with the first concentrate and tailing. Some scum found floating in the tailing box was put with the concentrate.

Weight of concentrate.. .. .	0.236 pounds
Analysis—Au.. .. .	263.60 oz. per ton.
Content—Au.. .. .	0.03110 oz.
Weight of tailings.. .. .	10.75 pounds
Analysis—Au.. .. .	1.16 oz. per ton.
Content—Au.. .. .	0.00623 oz.
Gold in feed used.. .. .	0.03966 "



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Two 1,000-gram lots of the above tailing, crushed to pass 100 mesh, were cyanided for eight hours in a 0.23 per cent solution and then decanted, washed, and cyanided for another eight hours with fresh solution.

First lot—	
Tails after 2nd cyanidation—Au.. . . .	0.10 oz. per ton.
Second lot—	
Tails after 2nd cyanidation—Au.. . . .	0.10 oz. per ton.
Recovery—	
1. By tabling.. . . .	83.3 per cent.
2. By cyanidation.. . . .	15.3 "
Loss.. . . .	1.4 "

Test 6.—10.10 pounds of original ore were crushed to pass 40 mesh, some metallica being obtained on the screen. The - 40-mesh material was sampled and the remainder, 9.47 pounds, was tabled on a small Willey table, the procedure being the same as in the tabling in test No. 5.

Gold in metallica from 10.10 pounds.. . . .	68.35 mgs.
" " " 9.47 " . . . . .	64.07 "
=	
	0.00206 oz.
Weight of concentrate.. . . .	0.196 pounds.
Analysis—Au.. . . .	228.41 oz. per ton.
Content—Au.. . . .	0.02238 oz.
Weight of tails.. . . .	8.77 pounds.
Analysis—Au.. . . .	1.19 oz. per ton.
Content.. . . .	0.00522 oz.
Analysis of -40 material—Au.. . . .	5.85 oz. per ton.
Metallica + 40-mesh corresponded to.. . . .	0.43 oz. per ton.
<hr/>	
Analysis feed used.. . . .	6.28 oz. per ton.
Gold in feed used= . . . . .	0.02974 oz.

Two 1,000 gram lots of the above tailing crushed to pass 100 mesh were cyanided for eight hours in a 0.23 per cent solution and then decanted, washed, and cyanided for another eight hours with fresh solution.

First lot—	
Tails after 2nd cyanidation—Au.. . . .	0.08 oz. per ton.
Second lot—	
Tails after 2nd cyanidation—Au.. . . .	0.16 oz. per ton.
Recovery—	
1. In metallica.. . . .	6.9 per cent.
2. By tabling.. . . .	75.5 "
3. By cyanidation.. . . .	15.8 "
Loss.. . . .	1.8 "

TABLING AND FLOTATION.

Test 7.—A small flotation test was made upon 500 grams of table tails from test No. 6 ground to pass 100 mesh.

Weight of concentrate.. . . .	5.35 grams.
Analysis—Au.. . . .	71.00 oz. per ton.
Content—Au.. . . .	0.000419 oz.
Weight of middling.. . . .	36.0 grams.
Analysis—Au.. . . .	4.12 oz. per ton.
Content—Au.. . . .	0.000164 oz.
Weight of tails.. . . .	456.0 grams.
Analysis—Au.. . . .	0.10 oz. per ton.
Content—Au.. . . .	0.000050 oz.
Gold in feed used.. . . .	0.000656 "
Recovery—	
1. In metallica.. . . .	6.9 per cent.
2. By tabling.. . . .	75.5 "
3. In flotation concentrates.. . . .	11.6 "
4. In flotation middlings.. . . .	4.6 "
Loss.. . . .	1.4 "



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## FLOTATION AND TABLING.

*Test 8.*—1,500 grams of original ore were crushed to pass 40 mesh, and some metallics were obtained on the screen. A flotation tail was then made upon the -40 material.

Gold in metallics. 10.50 mgs. . . . .	0.000627 oz.
Weight of concentrate. . . . .	56 grams.
Analysis—Au. . . . .	45.22 oz. per ton.
Content—Au. . . . .	0.002791 oz.
Weight of middling. . . . .	89 grams.
Analysis—Au. . . . .	10.02 oz. per ton.
Content—Au. . . . .	0.000983 oz.
Weight of tailings. . . . .	1,403 grams.
Analysis—Au. . . . .	4.20 oz. per ton.
Content—Au. . . . .	0.006495 oz.
Gold in feed used. . . . .	0.011607 "

Thirteen hundred and four grams of flotation tailings were tabled upon the small Wilfley table, the procedure being the same as in the tabling in test No. 5. In this tabling no scum was found in the tailing box.

Weight of concentrate. . . . .	15 grams.
Analysis—Au. . . . .	399.21 oz. per ton.
Content—Au. . . . .	0.00660 oz.
Weight of tailings. . . . .	1,262 grams.
Analysis—Au. . . . .	0.22 oz. per ton.
Content—Au. . . . .	0.00031 oz.
Gold in feed used. . . . .	0.006604 "
Recovery—	
1. In metallics. . . . .	5.8 per cent.
2. In flotation concentrate. . . . .	25.6 "
3. In flotation middling. . . . .	9.0 "
4. In table concentrate. . . . .	56.9 "
Loss. . . . .	2.7 "

*Conclusions.*

The above tests show that the ore as represented by the small lot submitted can be treated in a number of ways with success, and the selection will depend to a large extent on the situation of the property and other local conditions.

The ore contains values in gold to the extent of \$135 per ton, and as 80 per cent of this can be recovered by amalgamation, it is obvious that amalgamation would be adopted as the first stage in the treatment.

The ore contains mineral in the form of arsenopyrite, chalcopyrite, galena, and sphalerite to the extent of 1.5 per cent by weight, and this mineral constituent can be concentrated on tables and a high grade concentrate obtained, carrying practically all that remains of the gold values after amalgamation. This seems feasible as the second stage of the treatment.

It has been proven that the tailings after amalgamation and concentration, reground to 100 mesh can be readily cyanided with a recovery of any values remaining.

It has also been proven that from the tailings after amalgamation and concentration, reground to 100 mesh, the remaining values can be concentrated by flotation.

Which of these latter methods is adopted will depend on local conditions.



## III.

## REPORT OF THE CHEMICAL LABORATORY.

H. C. MABEE, *Chemist in charge.*

During the earlier part of the year 1919 the work of the chemical laboratory of this division was, for the most part, a continuation of that of the previous year. This included the examination and analysis of a large number of metalliferous ores and non-metalliferous minerals from the Canadian Munitions Resources Commission in the completion of their several investigations during the previous year; also a number of samples of graphite, barite, and other non-metallic minerals from the staff of the Division of Non-metalliferous Deposits, Sussex street. In addition, the regular activities of the Ore Dressing and Metallurgical Division throughout the year have fully occupied the attention of the staff of the chemical laboratory.

Through the loss of Mr. Graham, who left the service in May, and the resignation of Mr. Coyne, in October, the staff was reduced to two chemists, and these vacancies were still unfilled at the close of the year.

Owing to the lack of sufficient help, it has been impossible to comply adequately with the demands of the Ore Dressing Division. In most cases expeditious tests on shipments of ore are of prime importance; but as this involves a large amount of sampling and careful laboratory attention, without sufficient chemical assistance, prompt results are impossible. If the best results are to be obtained from the Ore Dressing Laboratories, it is necessary that additional help should be provided in the chemical laboratory.

The laboratory accommodation has been increased to a small extent by the rearranging and equipping of a special room for an assay laboratory. This room, while not as conveniently located as might be desired, nevertheless fills a very great need. If, however, the work of the Ore Dressing and Metallurgical Division is to develop to meet the increasing demands of the mining industries, it is extremely urgent that entirely new laboratory buildings should be built to replace the scattered, temporary accommodation now available.

The laboratory equipment has been increased during the year by the following apparatus: two double door aluminium desiccator ovens; one Braun four-unit electrolytic apparatus with revolving anodes, including four platinum cylindrical gauze cathodes, and four platinum anodes; one oil-fired melting furnace, and one muffle furnace, built in place.

The total number of samples from all sources, submitted for analysis during the calendar year, was 814, involving over 3,000 determinations. The ores were as follows:—

Bauxite, 2 samples.

Determined—silica, iron, alumina, and titanium.

Barite, 15 samples.

Determined—barium sulphate, silica, lime, and magnesia.

Chromite, 8 samples.

Determined—chromic acid, and sulphur.

Copper, 92 samples.

Determined—copper, and iron.

Fluorite, 20 samples.

Determined—calcium fluoride, calcium carbonate, strontium sulphate, silica, and barium sulphate.



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Gold, 74 samples.

Determined—gold.

Gold-Cobalt, 9 samples.

Determined—gold, cobalt, arsenic, nickel, and molybdenum.

Gold-Platinum, 55 samples.

Determined—gold, and platinum.

Graphite, 167 samples.

Determined—carbon, and iron.

Iron, 4 samples.

Determined—iron, silica, and phosphorus.

Infusorial earth, 1 sample.

Determined—silica, alumina, iron trioxide, lime, magnesia, and loss on ignition.

Manganese, 100 samples.

Determined—manganese, iron, silica, phosphorus, and sulphur.

Molybdenite, 117 samples.

Determined—molybdenum sulphide, and molybdenum trioxide.

Nickel-Copper (ores and sinter), 40 samples.

Determined—nickel, copper, sulphur, and sulphur trioxide.

Platinum, 11 samples.

Determined—platinum, and gold.

Pyrite (iron pyrites), 41 samples.

Determined—sulphur.

Rock, 9 samples.

Determined—silica, iron, alumina, and lime.

Tungsten, 20 samples.

Determined—tungstic oxide.

Zinc, Lead, 30 samples.

Determined—zinc, lead, and iron.



## CERAMIC DIVISION.

JOSEPH KEELE, *Chief of Division.*

### I.

#### INTRODUCTORY.

The field and laboratory work of the Ceramic Division during the past year consisted in an investigation of available deposits of raw materials used in the ceramic industries. These materials include clays, shales, feldspar, quartz, sandstone, limestone, talc, bauxite, magnesite, etc.

During a part of the summer a systematic survey was made of all the available structural materials in Dundas, Stormont, and Glengarry counties, Ontario, in order to ascertain the nature, extent, and quality of those deposits suitable for the extensive structures proposed in connexion with the power development on the St. Lawrence river. A brief summary of these materials is given in the following pages.

A survey was also made of the Mattagami and Abitibi rivers in northern Ontario in order to examine the deposits of high grade clays on those streams.

A description of samples of fire and pottery clays, with tests, from near the Long Portage in Mattagami river is given in the Summary Report of the Mines Branch for 1918. Fireclays were discovered by the writer at two other localities on the Mattagami river during the examination in 1919.

The laboratory work of the division consisted principally in testing samples of clay and shale collected by the writer, and by members of the Geological Survey. About fifty samples of clay were tested for various people throughout the Dominion. The facilities offered by the clay testing laboratory are now freely taken advantage of by the general public.

Owing to the difficulty in securing qualified assistants for the laboratory, very little research work or special experiments were carried on. A good deal of work in art pottery, however, was accomplished, and collections of glazed pottery were sent to the Technical School Museums at Halifax and Regina to illustrate the uses of the high grade clays which occur in the Provinces of Nova Scotia and Saskatchewan. The principal part of the work on pottery was done by Miss M. E. Young.

The services of Mr. R. T. Elworthy of the Chemical Division were secured for a short time to carry on some experiments on highly colloidal clays. Mr. Elworthy has also prepared a brief statement for this report concerning the sources of alumina, and the uses in the various industries.

A list of the various clay products made in Canada, and their values, together with the amount of imported clay products and other ceramic wares, is published in the Annual Report of the Mineral Resources and Statistics Division of the Mines Branch.



## II.

## BRITISH COLUMBIA.

## Residual Clays.

## BAKER CREEK, CARIBOO.

In the Summary Report for 1918, an account was given of white and grey burning residual clays from Chimney creek, Lillooet. Although these deposits contained refractory clays, they were of small extent. Mr. Reinecke, of the Geological Survey, who examined and sampled these clays, continued the search for high grade materials in the same region during the summer of 1919. He found large deposits of whitish, residual clays in the canyon on Baker creek, on lots 8651 and 8654.

These clays, like those on Chimney creek, are the result of the decomposition of impure quartzites of the Cache Creek series, and are found intermingled with rock fragments in various stages of decay, so that to render them usable they have either to be washed and screened, or else the whole deposit, including the rock fragments, must be ground to powder in a ball mill. The clay samples from Baker creek were silty, and contained very little true clay substance, hence they were difficult to mould; furthermore, the clays did not burn to white colours, and were not refractory.

## WILLIAMS LAKE, CARIBOO.

The most extensive deposit of white burning residual clay found up to the present in British Columbia is said to occur in the vicinity of Williams lake. A quantity of this material was taken to Vancouver for experimental purposes, and the results obtained in white ware body trials were promising.

For the manufacture of white ware goods, such as pottery, wall and floor tile, etc., this clay has to be mixed with a certain proportion of feldspar, and a white-burning, plastic clay, such as the one from Quesnel, described below.

## Fireclays near Prince George.

A series of clay beds, probably of Tertiary age, outcrop on the immediate west bank of the Fraser river in lot 3991, 30 miles above Prince George. The outcrop extends for about 1,000 feet along the river at the point sampled.

The following section was measured by Mr. L. Reinecke, of the Geological Survey:—

River gravel and boulders.. . . .	4—8 feet.
Very plastic white clay.. . . .	2—6 "
Sandy, greyish white clay.. . . .	2 "
Bluish grey clay.. . . .	3 "
Talus covered slope to water.. . . .	7 "

The horizontal extent of the beds underneath the flat terrace that forms the top of the gravels is not known. A sample was taken of the upper white clay bed, which has a thickness, in places, of 6 feet.

This clay is sandy in texture, and of medium plasticity, but its working qualities are good.

It burns to a nearly white strong body, at cone 7, with a total shrinkage of only 6 per cent, and absorption of 14 per cent. The material is intact when raised to a temperature that softens pyrometric cone 26—approximately 3,000 deg. F.—so that it is a fireclay.



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A good commercial fire brick could be made from this material, or it could be used for face brick, or other high grade clay products.

In order to make the deposit available, a wagon road  $1\frac{1}{2}$  mile long would have to be built to connect with the Prince George-Giscome Portage road, at a point at about 22 miles from Prince George. The most feasible method of transport, however, is by scow down the river to Prince George, as there is a steamboat channel all the way down.

### Pottery Clay near Quesnel.

On the west side of the Fraser river, about 8 miles above Quesnel, the banks rise to a height of 500 feet. Near the top of the bank there is a white clay bed about 20 feet thick, exposed for a length of 50 feet. This deposit was examined and sampled by Mr. Reinecke in 1919, who states that there is only about 2 feet of soil or overburden on the clay. The banks are slumped in places, and clay beds associated with infusorial earth beds occur at several different levels.

The white clay is very plastic, and works and dries well. It burns to a white porous body at all temperatures up to the softening point of cone 7—approximately 2,300 deg. C. When burned to this temperature it has a total shrinkage of 6 per cent, and an absorption of 16 per cent.

This clay begins to soften at cone 15, and is completely fused at cone 18—about 2,700 deg. F., so that it is only semi-refractory, and cannot be classed as a fireclay.

The chief interest of this clay, however, is that it keeps its white colour when burned to a comparatively high temperature, and since it has good plasticity, can be used as an ingredient for a pottery body in the manufacture of white ware. In other words, it might take the place of a ball clay if nothing better was available.

It could probably be used for the manufacture of stoneware goods, but it would have to be burned to about cone 9 or 10 in order to produce a dense or vitrified body.

The white colour and fine grain of this clay also suggests its use as a paper filler.

### Brick Clays.

Several samples of clay received through Mr. Weston Coyney of Prince Rupert were collected at Terrace and Lakelse.

These were evidently lake or estuarine clays, the samples taken from the upper part of the deposits being reddish in colour, while the lower portion was lead grey.

These clays have good plasticity and working qualities, and appear to be free from pebbles or coarse grit. They burn to a fine red colour and dense body at the ordinary temperatures of brick burning, while the shrinkages are within practical limits.

As nearly as could be judged by the small samples of material submitted for examination, they appear to represent the best brick clays from British Columbia which have so far passed through the laboratory. On account of their smoothness and good tensile strength in the raw state, these clays could be used for the manufacture of field drain tile, and possibly for hollow building blocks.

The deposits are said to be extensive, and are conveniently situated to the railway line, about 90 miles east of Prince Rupert.

### Fullers Earth.

Fullers earth is a clay-like material which obtains its name from its original use in fulling cloth. Its principal use in the industries of the present time is in bleaching, clarifying, or filtering fats, greases, and oils.



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The occurrence of fullers earth has hitherto never been recorded in Canada, the supplies for the packing houses being imported either from England or the United States.

The writer has found several materials having the appearance of fullers earth, but when samples were tested in the laboratory or submitted to a firm of packers they failed to act as clarifiers of oil.

The only sample of earth which appeared to be an effective bleacher for oils was recently sent by Mr. Bertrand Chester, Meadows Ranch, Seven Lakes P.O., Cariboo, B.C. In appearance it was a friable, yellowish-brown material, resembling impure diatomaceous earth. Nothing is known at present regarding the extent of the deposit or its availability for transportation.

The value of the fullers earth imported into Canada in 1919 was about \$20,000.

## III.

## CLAYS AND SHALE IN THE VICINITY OF FORT WILLIAM AND PORT ARTHUR.

There is an abundance of stoneless clay, suitable for the manufacture of brick and tile, along the lower reaches of the Kaministiquia river; in fact there is no other point in Ontario so well supplied with a good convenient brick material, except the city of Toronto.

A good opportunity for examining the clay deposits is afforded by the excavation made for brickmaking at the three brick plants situated close to the river at the outskirts of Fort William. The best section is at the Gownlocks plant, where 76 feet in thickness of stratified clay was exposed. The upper part of the clay is composed of smooth, olive clay layers, interlaminated with reddish bands of clay of silty texture, while the middle part of the bank is of greyish stratified clay, rather more silty and shorter in texture than the top clay. The lowest part is brownish to grey silty clay, more compact and massive than the upper clay, but shows rough lamination. It is sandy in places, but the clay, as a whole, is plastic enough, but not nearly so smooth and plastic as the upper portion.

No stones, pebbles, or concretions, could be detected in any portion of the deposit. About 4 or 5 feet of yellow sand overlies the clay.

The stratified brick clay deposit is underlain by coarse river gravels, but the gravels are at such a depth that they are not exposed on the lower reaches of the river. On going up stream, however, the clay thins out, and the gravels rise toward the surface. At Rosslyn, about 6 miles north of Fort William, the gravels come to within about 6 feet of the surface.

The clay deposit at the pits of the Superior Brick and Tile Company's plant, consists of about 5 feet of smooth plastic red clay, interlaminated with red sandy clay. The coarse river gravels lie immediately under the clay, and it is overlain by 2 to 3 feet of reddish sand.

The clay disappears a short distance beyond Rosslyn, while the gravels rise to the surface.

No clay appears beyond the point near the Canadian Pacific Railway line until about 5 miles west of Kaministiquia station, or half a mile beyond Mattawin river bridge. A thin deposit of stoneless red clay begins here, which thickens considerably toward Finmark, 4 miles farther on. This red clay deposit extends as far west as Buda, 8 miles west of Finmark.



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A sample of the red clay was collected near Sunrise section house. The clay at this point appears to lie in a broad depression in the Archæan upland, through which the Mattawin river flows.

The base of the clay is near the level of the railway track, and consists of layers of coarse grey sand interstratified with thin clay layers, while the upper part of the deposit is all red clay, rather massive in structure, the whole section here being about 25 feet thick.

The red clay is exceedingly smooth, plastic, and rather sticky when freshly dug from the bank. It appears to be quite stoneless, but contains a few scattered concretions.

This clay is very stiff and difficult to work, and its shrinkage on drying is too great. It burns at low temperatures, to a porous but hard, red body, and is liable to become fire checked. It would, however, be suitable for making common building brick, if mixed with sand in the proportion of 2 parts clay to one part sand, but the clay could not be worked without the sand addition. This clay is not as good a brick material as the clay at Rosslyn.

There appears to be quite a large deposit of clay on the bank of the McIntyre river on the property of the Canadian Resources Development Company of Port Arthur. This deposit is about  $1\frac{1}{2}$  mile from the shore of Lake Superior, and is situated in the municipality of Port Arthur.

The borings made by the company are said to have proved the thickness of the clay to be 24 to 32 feet. Only about 6 feet of the upper portions of the deposit was available for sampling when the writer visited the locality.

It is a rather stiff, red to yellowish, sandy clay in the upper part, and bluish stratified clay below, which contains a 2-inch streak of fine gravel.

About a foot or two of brownish-red, sandy loam overlies the clay, and about 10 per cent of this was included in the sample with the average of the top and bottom clays.

This clay is not so plastic as the clay at Fort William, being short in texture when wet; but it has the advantage of low shrinkage, and will stand fast drying without checking, which the Fort William clay does not.

It burns to a pale red and very porous body, which appears to be due to containing a rather high percentage of carbonate of lime.

This clay would probably be suitable for the manufacture of common building brick made by the soft-mud process. Its poor colour and high porosity would exclude it from being used for face brick, but it might be used for backing and partition brick.

### Shale Deposits.

Shale, suitable for the manufacture of clay products, occurs on the east shore of Thunder Bay, Lake Superior, about 15 miles east of Port Arthur and Fort William.

The shale outcrops at the water edge, and is exposed for several miles along the shore. It is overlain by a great thickness of conglomerate, sandstone, and red shale, but the upper material contains no beds suitable for the manufacture of brick or tile.

The shale exposed along the shore reaches a thickness of 40 feet in places, and an abundant supply could be mined for many years, and brought across the bay in barges. The material is greenish grey in colour, and weathers into thin flaky layers with films of yellowish clay between.

A large sample of this shale was tested at the Mines Branch laboratories, and found to be satisfactory for working up into brick and hollow ware shapes. When ground and mixed with water, the material develops fairly good plasticity and working qualities. Its drying qualities are good and the shrinkage low. It burns to a good



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strong body, with a fine red colour. The burned ware is liable to show a white seum, but this can be eliminated with the addition of a small amount of barium carbonate. This shale has not a very long range of vitrification, consequently it would not be safe to attempt the manufacture of vitrified products.

It would be found advantageous to mix some of the plastic surface clay at Fort William with the shale, as this mixture would flow through the dies of the machine easier, and would require less power than if all shale were used. A mixture of half shale and half clay would be found suitable for making large hollow blocks, and this method would reduce the amount of shale that would otherwise have to be ground.

It is possible that this shale could also be used for the manufacture of heavy red floor tile or roofing tile, but for this purpose it would have to be ground much finer than if used for brick.

### Slate.

Mount McKay, in the vicinity of Fort William, is built up largely of dark Animikie slate beds. These beds are not true slates, but are really hard, gritty, shales, which do not show any plasticity when finely ground and mixed with water. An attempt was made to utilize these slates by working them up into brick by the dry pressed process. A plant was actually built for this purpose at the base of Mount McKay, and operated for a short period.

Unless the brick made from this slate is burned to nearly the point of vitrification, it will be too soft and weak for structural purposes; but as the softening point of the slate is low, the brick made from it will become overfired and deformed, especially in the upper part of the down-draft kiln, when approaching the temperature necessary for vitrification. Furthermore, owing to the short vitrification range of the slate, the bricks in the lower part of the kiln may be far too soft, while the upper ones are overfired.

The important difference between a shale and slate is, that the former is plastic when ground and moistened, while the latter is not; consequently, some bonding material, such as plastic clay, must be added to the ground slate when utilized for brickmaking. The obvious remedy in the case of the Mount McKay brick plant would be to add some plastic surface clay to the slate while it was being ground in the dry pans, and this mixture could be relied upon to make a much better brick than if slate alone was used.

### Clay-working Industry.

There were formerly five plants making burned clay products and one sand lime brick plant in the vicinity of Fort William and Port Arthur.

During 1919 only three brick plants were in operation, and none of them ran at full capacity, but an increased production is expected during the following year.

The large deposits of stratified clay on the banks of the Kaministiquia river at West Fort William consist of good raw material for the manufacture of common red building brick. This clay slakes readily when wet, and is not inclined to be lumpy. It runs easily in the machine, and slips well from this mould. These properties facilitate production, and it is said that as many as 50,000 bricks have been made in a day on a Martin machine at the Alsip plant. This is probably the highest record in Canada from a soft-mud brick machine. A very good red stock brick is produced at the various plants at West Fort William. The hard burned ones are, of course, the best; they have a good ring when struck together. The moulding sand is obtained from the top of the clay deposits, and as it burns to a rich red, it imparts this colour to the surfaces of the brick, but in those portions of the kiln where the air supply is



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limited the reducing action turns the colour into fine dark and flashed shades. These variegated shades which range from almost black to red in the burned brick, are in great demand, especially for the best class of dwellings.

Underburned brick made from this clay are undesirable, on account of their low strength and poor colour, which even the moulding sand does not always conceal.

The plants in West Fort William make only soft mud or sand moulded brick. The brick are mostly air dried on racks and pallets. The burning is done in scove kilns, the fuel used being wood.

This method of burning is simple, and involves no outlay of capital for kilns or overhead expenses during the winter months, when the plants are closed. There is a great deal of waste, however, in the scove kilns, due to broken overburned brick in the fire arches, as well as an undue quantity of soft brick. Better results are obtained in permanent, round, or rectangular down-draft kilns, fired with wood and coal where a saving of fuel is effected and a larger percentage of hard brick produced. These kilns can also be constructed without much extra expense, so that the waste heat from cooling kilns can be drawn off by means of underground flues, and sent into the brick driers; or the waste heat can be used to preheat another kiln.

The plant of the Superior Brick and Tile Company is situated at Rosslyn, about 6 miles north of Fort William. This is a well equipped plant, with 6 down-draft kilns, having a capacity of 80 to 90 thousand brick each. Provision is made to take the waste heat from the cooling kilns to the brick drying tunnels by means of a suction fan.

A good quality of wire-cut, rough faced, red building brick is made at this plant. Some fine effects of colour are produced on the faces of the brick in the upper part of the kiln, where some of the brick are of a gunmetal shade.

Unfortunately, the clay will not stand overfiring, consequently the brick at the top of the kiln are liable to be partly melted or stuck together if the finishing temperature is carried too high.

The clay at this plant burns to a hard strong body at low temperatures, and is very smooth and plastic, so that it would make a good field drain tile, or hollow building brick for interior construction.

This clay also appears to be smooth enough to be used for the manufacture of flower pots.

The utilization of the plastic Animikie shale from Sawyer Bay should provide a means for increasing the range of clay products made in this district. This shale, or a mixture of clay and shale, should give satisfactory hollow building block or fire-proofing, together with rough faced and dry-press building brick. It is also possible that when finely ground this shale could be used in the manufacture of floor tile or roof tile.

#### IV.

#### KAOLIN IN GATINEAU VALLEY, QUEBEC.

In 1909, development work was begun on the extensive deposit of kaolin at St. Remi d'Amherst, in the Province of Quebec<sup>1</sup>.

As a result of the opening up of this valuable deposit, some prospecting was done in the region, with the hope of locating other occurrences of kaolin of workable dimensions; but so far, this search has proved to be fruitless. Prospecting for deposits

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<sup>1</sup> Mines Branch Summary Report 1916, p. 105, Geological Survey, Memoir 113.



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of this character is carried on with difficulty, owing to the glacial drift which prevails almost everywhere, and to the forest growth which is widespread in the rugged and sparsely settled region where the kaolin is likely to occur, so that boring or test pitting becomes necessary. Surface indications of the presence of kaolin can sometimes be gained by an inspection of the banks and bottoms of rivers and streams during the lowest stages of water.

The occurrence of a small deposit of kaolin in the Gatineau valley has been known for several years. It is situated in the township of Low on an island in the Gatineau river above Plomb falls, 35 miles north of the city of Ottawa.

The kaolin outcrops on the north end of the island where about 2 feet in thickness can be seen for a distance of 200 feet during low water. The kaolin is overlain by river gravels, sand, and boulders, and no bed-rock is visible in the vicinity.

The crude kaolin, when washed, yields about 35 per cent of fine material, which passes a 200-mesh screen. The coarse part of the deposit consists of angular quartz grains, a little weathered feldspar and small quantities of pyrite and mica. The finest washed material is silty, and contains very little true clay substance, consequently its plasticity is low. The washed clay burns to a greyish-white body at cone 7, with a total shrinkage of 15 per cent and an absorption of 13 per cent.

A portion of the washed clay was used in a standard pottery body burned to cone 9, and glazed at cone 6; but the colour was not good, and numerous minute black specks appeared on the surface under the glaze.

This clay would require a more thorough purification, besides simple washing before it could be used in a pottery body.

The colour of the clay is not white enough to permit its use as a paper clay.

The sample tested was taken from the outcrop, and no boring was done on the deposit; so that it is impossible to say anything about its extent, at present.

## V.

## ALUMINIUM AND ITS SOURCES.

R. T. ELWORTHY.

Aluminium is rapidly attaining a position of the first rank among those non-ferrous metals which have made possible some of the greatest advances in the arts and industries that the world has seen in recent times.

The preparation of aluminium on an industrial scale has only been carried on for about thirty years. In 1918, over 222,000 tons of the metal were produced.

Its uses are manifold. On account of its lightness—it is only one-third as heavy as steel—and especially of its strength, when alloyed with small amounts of copper and magnesium, it is employed largely in the construction of automobiles and aeroplanes; such as engine parts, and light framework.

Aluminium is employed extensively in the construction of industrial chemical plants, chiefly because of its resistance to the action of all acids except hydrochloric. As it is unaffected by vegetable acids, it is in increasing demand for apparatus used in the preparation of food products, and for kitchen utensils.

The readiness with which aluminium combines with oxygen, and the great evolution of heat in the formation of the oxide, are the basis of several important industrial uses, such as a deoxidizing agent in steel casting, and in the "thermit" welding process. Aluminium powder is a constituent of certain high explosives such as "ammonal," which is composed of 93-97 per cent ammonium nitrate, and 4-6 per cent of the metal.



Many of its compounds are industrially important. The alums, double salts of aluminium sulphate, and some other metals are widely used, such as potassium alum or burnt alum in certain food products, ammonia alum in medicine, and soda alum in the textile and paper industries.

Quantities of aluminium sulphate are used in sizing paper, also as a mordant in dyeing. In water purification, it is used in the form of aluminium hydroxide or hydrated alumina. Aluminium chloride is employed in petroleum refining, and in the manufacture of some organic dyes. Aluminium resinate, aluminium stearate and palmitate, have uses in the varnish and waterproofing trades.

Alumina, the oxide ( $Al_2O_3$ ), found naturally as corundum, is widely used as an abrasive, on account of its hardness as is also the less pure oxide emery. Sapphires and rubies are essentially corundum, containing traces of impurities, and the artificial production of these gems from alumina is becoming an established industry.

Alumina is also a valuable refractory material. Aluminium silicate is the principal constituent of clays, hence forms one of the chief ingredients in bodies, glazes, and enamels, for the pottery industry.

In the manufacture of paints, aluminium hydroxide is the most important carrier for lake pigments.

PROCESSES OF MANUFACTURE.

Aluminium was not isolated in any quantity until 1854, and the rapid development of its utilization only dates from 1886, when C. V. Hall in America, and Heroult in France, almost simultaneously established on an industrial scale, the present method of preparation by electrolysis of bauxite—the naturally occurring hydrated oxide—dissolved in a bath of molten cryolite (sodium aluminium fluoride).

Electrolytic plants for the manufacture of aluminium exist in most of the principal countries, and usually situated near a source of electric energy. Thus in Canada, the Northern Aluminium Company have a large plant at Shawinigan Falls, Quebec, which produces about one-tenth of the world's supply of the metal.

The following table<sup>1</sup> shows the principal producers in 1918:—

Country.	Metric tons.	Raw Material.	Source.
United States... ..	102,000	Bauxite.	Georgia, Alabama, and Arkansas.
Canada... ..	15,000	"	" "
France... ..	22,000	"	France.
Switzerland... ..	15,000	"	
Austria... ..	8,000	"	Austria.
Italy... ..	8,000	"	Italy.
Great Britain... ..	14,000	"	France and U.S.A.
Norway... ..	18,000	"	France and U.S.A.
Germany... ..	20,000*	"	Austria and Germany.

Two recent papers<sup>2</sup> give details of the processes employed in Europe, and describe the method of purification of the raw bauxite; the construction of furnaces; electric circuit and power requirements; composition of bath; and manufacture of carbon electrodes. These processes are essentially the same in all countries.

RAW MATERIALS OF ALUMINIUM.

This pre-eminent position to which aluminium is advancing seems justified when the extent of the distribution of the metal in the earth's crust is considered. Although aluminium is never found in the native state, combined with oxygen and silica, it is very abundant, and is an essential constituent of nearly all rocks.

<sup>1</sup> Estimated production in 1918. The Mineral Industry, p. 15, 1919.  
<sup>2</sup> Aluminium deposits and the production of aluminium, Engineering (London) Vol. 166, pp. 163-165, 191-193, 218-220, 1918. Aluminium Manufacturing Processes used in Europe, O. Nissen, Chem. and Met. Engineering, Vol. 19, pp. 804-805, 1918.



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Dr. F. W. Clarke has estimated that it forms 7.84 per cent of the earth's crust, and is therefore third in the list of distribution of the elements—inferior only to oxygen and silicon, and is the most abundant of all metals.

It is a primary constituent of the feldspars and micas, also of their decomposition products—the clays. It widely exists as the oxide corundum, and the hydrated oxide bauxite.

The following table gives a list of the principal common minerals, containing aluminium.

They are seldom found uncontaminated, and are usually combined with other rock constituents. But sufficiently large deposits of relatively pure material for industrial purposes are found in certain localities.

Mineral.	Nature.	Locality.	Alumina content.
Bauxite. . . . .	Hydrated oxide of alumina. . . . .	France, British Guiana, Georgia, and Arkansas, U.S.A. . . . .	50–80 per cent.
Pure china-clay. . . . .	Aluminium silicate. . . . .	England. . . . .	39
Nepheline syenite. . . . .	Potassium, sodium aluminium silicate. . . . .	Ontario. . . . .	33–22 Per cent.
Labradorite. . . . .	Sodium calcium silicate. . . . .	Norway, Labrador, Canada. . . . .	30–27
Glacial clay. . . . .			10–20

Other important minerals containing aluminium in appreciable quantity are cryolite, diaspore, and alunite; but these are not so widely distributed or abundant as those with a lesser content of aluminium, such as the feldspars. Alunite occurs on Kyuquot sound in Vancouver island, but the occurrence of cryolite and diaspore have not yet been reported in Canada.

Although bauxite has been diligently sought for in those portions of Canada where it is most likely to occur, it has not been found up to the present.

Notwithstanding the varied compounds of aluminium which occur in nature, the metal has up to the present time only been prepared on an industrial scale, from one raw material, namely, bauxite. In 1918, the world's production of bauxite was over 650,000 tons, and probably four-fifths of this was treated for the isolation of aluminium.

It appears interesting to look for the reason of this apparent neglect of the other raw materials comparatively rich in alumina. In the first place, bauxite is the richest ore; in the second place, most of the other minerals contain aluminium as aluminium silicate, usually combined with other silicates. These are very difficult substances to break down into their simpler constituents, and the resulting silica may be difficult to handle. But the problem has been the subject of much investigation, especially during recent years, and a satisfactory solution is by no means impossible.

The two chief sources of raw materials, other than bauxite, that offer the greatest possibilities, are the plagioclase feldspars and high grade clays. The following paragraphs briefly review recent attempts that have been made, using these materials.

## THE FELDSPARS AS A SOURCE OF ALUMINA.

Several large works have, for many years, been established in Norway, and produce about 15,000 to 20,000 tons of aluminium annually. Soon after the outbreak of war, in 1914, supplies of bauxite became difficult to obtain, and attention was directed to other sources of raw material. Eventually Professor V. M. Goldschmidt of the Mineralogical Institute, Kristiania, developed a process<sup>1</sup> for obtaining alumina from labradorite, a rock which is very plentiful in southwest Norway, and found relatively pure, containing only small amounts of iron bearing minerals.

<sup>1</sup> Nature. Vol. 104, p. 160, 1919.



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Labradorite is a feldspar composed of the silicates of aluminium, calcium, and sodium; it contains about 30 per cent  $\text{Al}_2\text{O}_3$ , and is comparatively easily soluble in acids.

Sulphuric acid was originally used, but the final process in brief was as follows:—

The raw material is treated with nitric acid of about 30 per cent strength, synthetically prepared from nitrogen and hydrogen, by the Birkeland and Eyde arc process. The calcium sodium aluminium silicates are broken down, soluble nitrates of these metals are formed, leaving insoluble silica.

The iron minerals are, for the most part, unacted upon. No details of best conditions for solution and for separation of the silica are given. After iron in the solution is removed, the nitrates are heated until the aluminium salt is decomposed (at a temperature of  $140^\circ\text{C}$ . under normal conditions), resulting in alumina and nitrous fumes. The fumes are recovered, and reconverted into nitric acid, when passed through the usual absorption towers.

The calcium and sodium nitrates are washed away from the alumina, and on evaporation, can be utilized as fertilizers. The alumina is dried and calcined ready for addition to the electrolytic bath.

The process appears to be of considerable value, as it is carried on in the vicinity of the nitric acid works, and where cheap material is available.

#### SUITABLE FELDSPARS IN CANADA.

Large masses of anorthosite, consisting of labradorite with negligible amounts of iron-bearing minerals, are known in Canada in the Provinces of Ontario and Quebec, where workable deposits of relatively pure material could be opened up similar in character to the Norwegian deposits; and the same process for the separation of alumina suitable for aluminium production or for the preparation of aluminium salts would be applicable, according to preliminary laboratory experiments.

Another material which has possibilities of great importance as a source of alumina is nepheline syenite. Nephelite itself contains a relatively high percentage of alumina, according to recent analyses, though the nephelite syenites which form the body of raw material would not run quite as high.

It is more soluble in acids than labradorite, but is not as plentiful.

Deposits occur in Hastings and Haliburton counties, in Ontario, and could be easily worked.

Possible methods of extraction of the alumina and potassium, comprise fusion with alkali and carbon in an electric furnace; solution in nitric or sulphuric acid; or treatment with chlorine, or even carbon dioxide under pressure.

There are no laboratory difficulties; the problem is mainly a technical one of the most efficient treatment consistent with lowest cost; a matter which can only be settled by large scale experimental work. The products would be alumina, potassium salts, and silica, all of which should be of value.

#### ALUMINA FROM CLAYS.

It will be seen from the table on page 111 that some clays contain almost as high a percentage of alumina as many of the bauxites that are treated as a raw material for aluminium preparation.

Many processes have been proposed and patented to utilize this source of alumina.

But the success of such processes on an industrial scale is still far from being an established fact, and it is certain that success will only be attained by a process using a pure clay as raw material.



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The common brick clays, or clays of glacial origin, are of no value whatever. They are relatively unweathered, and contain much undecomposed feldspar, too small an amount of alumina, and relatively large quantities of iron, lime, and magnesia. No process using such clays can offer any hope of success.

A suitable clay must carry little impure material such as silica, magnesium, and iron. The washed china-clay produced at St. Remi d'Amherst, Quebec, is an example of a very pure clay.

Many of the methods proposed, have, as their basis, the action of sulphuric acid on the clay, which after prolonged heating or treatment in an autoclave under pressure, dissolves much of the clay substance. Aluminium sulphate is the chief product, and after separation from the silica and other impurities, it is treated in various ways, and finally calcined to reduce it to alumina.

Other processes treat clay with strong caustic alkali, somewhat similar to the Baeyer method for the purification of bauxite, in which sodium aluminate is formed. From a solution of this compound, alumina can be obtained by the addition of lime, by freshly precipitated alumina, or by carbon dioxide or other gases.

In several of the most promising attempts mixtures of high grade clay or other aluminium mineral, salt or calcium chloride, and carbon in some form, such as charcoal or coke, are subjected to a high temperature in an electric arc or resistance furnace. The sodium aluminium silicates which result are then converted into sodium aluminate by treatment with lime or alkali, and finally into alumina by one of the standard methods.

A recent European process that appeared to have a great chance of success consisted in treating the clay with sulphuric acid, separating the soluble material, chiefly aluminium sulphate, and by adding ammonium sulphate the alum ammonium sulphate was precipitated, this salt being relatively insoluble. It was filtered off and decomposed on treating with ammonia into alumina and ammonium sulphate.

The alumina was dried and made ready for charging into the electrolysing furnaces, or converted into aluminium salts, as desired.

No commercial process utilizing clays as a source of metallic aluminium has yet been successfully developed.

## ALUMINIUM SALTS.

Alum, or potassium aluminium sulphate, was an industrial commodity even before the metal was isolated, and the manufacture of alum from alum shales was well established in England and Scotland in 1840.

The chief characteristic of the alum shales found in York-shire, and near Glasgow, was their large content of pyrites. After long weathering they were roasted in a copious draught, and the sulphuric acid that formed attacked the clay, decomposing it, and forming aluminium sulphate. The roasted mass was lixiviated, and by fractional crystallization and the addition of potassium or ammonium sulphate alum was separated in a pure form.

To-day such salts are more readily prepared from bauxite or china-clay by treatment with sulphuric acid.

The manufacture of aluminium sulphate and sodium aluminate salts, widely used in the textile industries, and in water purification, has already been referred to as steps in the purification of alumina.

Most of the other salts of aluminium, such as the acetate or chloride, are also prepared from bauxite, or from the metal itself, but they are relatively of small importance.



## VI.

## STRUCTURAL MATERIALS IN DUNDAS, STORMONT AND GLENGARRY COUNTIES, EASTERN ONTARIO.

BY

J. KEELE AND L. H. COLE.

## INTRODUCTORY.

Instructions were received by the writers, in the early part of 1919, to make a survey of a portion of the valley of the St. Lawrence river in Ontario and Quebec.

This work was undertaken at the request of the Power Board of Canada. The object of the survey was to locate and sample any deposits of materials which could be used for structural purposes, also to enquire into the character of the bed rock and the overlying unconsolidated formations, in so far as they affected the storage of water or the deepening and deflection of the present canal system.

The section investigated during the summer of 1919 lies in the counties of Dundas, Stormont and Glengarry, and consisted of a strip from 5 to 10 miles wide, along the St. Lawrence river between Morrisburg and Lancaster, a distance of 38 miles. As most of the materials of construction should be within wagon hauling distance of the proposed works, it was not considered necessary to go farther from the river than 5 miles, except along the lines of railways running northerly from the river.

It was found, at the outset, that it would be necessary to make a complete geological survey of the district, as no maps of this kind were in existence.

A map showing the bed-rock formations underlying that area in Ontario lying between the Ottawa and St. Lawrence rivers was published, on a scale of 4 miles to an inch, by the Geological Survey, in 1906. As this region, however, is almost entirely covered by unconsolidated material, and the bed-rock outcrops are so very small and scattered, the map was useless for the present purpose.

The unconsolidated materials consist entirely of glacial drift, mostly intact as deposited by the ice sheet which overspread the entire region.

Portions of the drift sheet, however, are modified by water action, either due to streams issuing from the melting ice sheet or to the effect of large water bodies which flowed into the valleys from the sea after the withdrawal of the ice; or, to recent drainage and weathering after the uplift of the region above sea level. It is the washed and sorted products of the glacial drift which furnishes the materials of construction, and these are sands, gravels, and brick clay.

**Brick Clays.**

The raw material for the manufacture of burned clay products is entirely confined to the stoneless clays washed from the boulder clay or glacial till of the region, and deposited in the deep water estuary which occupied the region during the marine submergence. These clay sediments are restricted in area, and are confined principally to isolated patches along the St. Lawrence river; but some of the patches occupy the floors of depressions extending inland. In the region under discussion these marine clays nowhere form such extensive plains as those along the Ottawa river to the north, or on the St. Lawrence river farther east.<sup>1</sup>

The principal clay deposits, convenient to the river, occur in the townships of Williamsburg and Osnabruck, in Dundas and Stormont counties. The clay in these

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<sup>1</sup> Keele, J., Clay and Shale Deposits of Quebec, Memoir 64, Geological Survey, Ottawa, 1915.



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localities is mostly exposed on the surface, and not covered by sand, as they often are.

In mapping the area of stoneless marine clay, it is often difficult to determine their extent, as they overlap and emerge into stony clay, so that frequent borings are necessary in order to determine whether a deposit is of sufficient thickness on which to start a clayworking plant.

As the stony clay in this region contains a large number of limestone pebbles, it must be rigorously excluded from brickmaking operations.

The following table gives the results of the physical tests made on the clay samples collected during the season of 1919.



Summary Table of Physical Tests on Surface Clays in Eastern Ontario.

Locality.	Lab. No.	Per-centage water required.	Per-centage of drying shrink-age.	Cone 010		Cone 06		Remarks
				Per cent fire shrink.	Per cent absorp-tion.	Per cent fire shrink.	Per cent absorp-tion.	
One mile east of Weaver Point, Dundas Co.....	687	26	6	0	14	1	14	Average of bank.
One mile east of Weaver Point, Dundas Co.....	687a	22	6	0	14	1	13	Upper portion of bank.
One mile east of Weaver Point, Dundas Co.....	687b	30	8.5	0	15	1	15	Lower portion of bank.
From stream bank 1 mile N.W. of Aultsville.	689	32	9	0	16	1	14	Good for drain tile
Bank of creek at Farrans Point, Stormont county.....	690	25	7	0	16	0	16	Average of bank.
Bank of St. Lawrence river, 1½ mile west of Dickinson's Landing.....	691	22	5	0	17	0	17	Burned colour is buff.
East end of Sheik island, St. Lawrence R.	692	37	10	1	15	.....	14	Upper 8 feet of bank.
East end of Sheik island, St. Lawrence R.	692a	38	10	1	18	.....	14	Lower 12 feet of bank.
Con. IV, lot 24, Cornwall tp.	693	37	10	1	14	3	2	Upper 6 feet of borehole.
Near quarries 1 mile N. of Moulinette.....	693a	40	10	1	17	5	7	Lower 8 feet of borehole.
Near quarries 1 mile N. of Moulinette.....	694	32	9	0	16	1	14	Good for drain tile.
Cornwall tp. lot 25, con. VI.....	695	27	8	0	15	1	14	Upper clay, good for tile.
Onabruk tp. lot 3, con. IV.....	696	20	5	0	14	0	14	Lower clay, burns buff.
Onabruk tp. lot 3, con. IV.....	697	38	13	1	13	6	1	Bloats on fast firing.
Charlottenburg, tp. con. I, bank of Grays ck.	697		8	.....	.....	1	14	1 part sand to 2 parts clay.
Charlottenburg, tp. con. I, bank of Grays ck.	698	27	8	1	12	1	13	Good for drain tile.
Lancaster tp. lot 30, con. V, Glengarry county	699	37	11	0	12	5	1	Cracks in drying.
Cornwall tp. con. V, lot 2, Stormont Co.....								
Charlottenburg tp. lot 3, con. IV, Glengarry county.....	700	37	10	0	18	3	14	Good for drain tile.



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## EXPLANATION OF PHYSICAL TESTS.

The clays were prepared for testing, by grinding, wetting, and working them, until the best working consistency for each sample was determined; and then moulded into test pieces 4" by 1½" by 1" in size. The clay requires different quantities of water for mixing, the amount varying according to the texture; the pasty, highly plastic clays requiring more, and the silty, open working ones, less. Lab. No. 691, is an example of the latter type, and 692, of the former. The clays that require a large quantity of water in mixing are generally hard to dry; and any of the clays taking 37 per cent or more of water, will probably crack on drying—when made up into brick shapes and set to dry, and furthermore, shrink too much. The cracking and shrinkage can generally be cured by the addition of sand; and two of the defective samples, namely, Nos. 697 and 699, were treated in this manner, and the figures in the table show that the shrinkage was considerably reduced, and the drying and burning difficulties were overcome.

When the test pieces were thoroughly air dried, they were set in a down-draft, coal-fired kiln, and burned for 32 hours. Standard pyrometric cones and a recording pyrometer were used as a measure of the heat treatment.

It was found that cone 010 went down at about 1,700 and cone 06 at 1,850 degrees Fahr., on the pyrometer.

The character of the burned body at the different temperatures is indicated in the table under the headings "percentage of shrinkage" and "absorption": the effect of the increasing heat being to make the test pieces smaller and denser, in most cases. Vitrification was accomplished in Nos. 693, 697, and 699, at the higher temperature, so that their capacity for taking up water vanished, and the pieces showed high shrinkage values.

The tests indicate that the drying shrinkage of most of the clays is too high, for when the percentage is 8 per cent or over, it is generally necessary to add sand for brickmaking purposes although it may not be always necessary in the case of thin ware like drain tile.

The time occupied in burning has an effect on the character of the burned clay body. If the time of firing is prolonged, a denser body is produced at a given temperature than in a shorter period of firing, hence test kilns do not give quite the same results as commercial kilns. In firing most of the red burning surface clays of Ontario and Quebec, the finishing temperature of the kilns varies from 1,650 to 1,800 degrees Fahr. If the temperature of the kiln should reach higher than this, most of the upper portion of the brick in down draft kilns would be softened and deformed.

## COMPOSITION OF THE CLAYS.

The chemical composition of the clays is not of much importance when testing them for the manufacture of burned clay products, as it gives no indication of how the various clays will behave during the different stages of preparation and burning. It may be necessary, however, to know the composition of the clay if it is to be used as an ingredient in the manufacture of Portland cement along with a suitable limestone or marl.

The following chemical analysis of samples taken from the bank at the east end of Sheik island, in the St. Lawrence river, will furnish a general indication of the composition of most of the stoneless clays of the Ottawa and St. Lawrence valley:—



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	692	692a.
Silica ( $\text{SiO}_2$ ) . . . . .	54.90	53.48
Alumina ( $\text{Al}_2\text{O}_3$ ) . . . . .	18.20	18.06
Iron oxide ( $\text{FeO} + \text{Fe}_2\text{O}_3$ ) . . . . .	6.64	7.36
Titanium ( $\text{TiO}_2$ ) . . . . .	0.83	0.84
Lime ( $\text{CaO}$ ) . . . . .	4.68	4.62
Magnesia ( $\text{MgO}$ ) . . . . .	2.62	4.62
Potash ( $\text{K}_2\text{O}$ ) . . . . .	3.78	3.33
Soda ( $\text{Na}_2\text{O}$ ) . . . . .	1.36	1.75
Carbon dioxide ( $\text{CO}_2$ ) . . . . .	1.32	1.46
Water at $105^\circ\text{C}$ . . . . .	1.68	1.54
Water above $105^\circ\text{C}$ . . . . .	3.22	2.76

No. 692—Average of upper 8 feet of bank.  
No. 692a—Average of lower 12 feet of bank  
Analyst.—Mr. A. Sadler, Mines Branch, Ottawa.

The iron, titanium, lime, magnesium, and the alkalies, potash and soda, are the fluxing impurities; while the silica and alumina are the refractory portions. The above clays contain 17 to 19 per cent of fluxing impurities, which make them readily fusible. Fire clays contain only 3 to 7 per cent of these impurities; but there are no clays of this class in the region.

There does not seem to be much difference between the top and bottom portions of the deposit, as regards chemical composition; but there is, generally, a difference in texture, the bottom clay being the coarsest grained.

The amount of lime and magnesia, together present, is quite large, but not large enough to interfere with the development of a good red colour in the burned product. When the amount of lime and magnesia together equals three times the amount of iron present in the clay, it will burn to a buff colour. All the surface clays and most of the underclays in the region, burn to red colours. The two samples of silty, calcareous clays—691 and 696—are both underclays, with a sufficiently high lime and magnesia content to cause them to burn to buff colours.

CHARACTER AND DISTRIBUTION OF BRICK CLAY.

The upper portion of the marine, stoneless clays, is usually quite plastic and smooth, and works up into a very stiff paste when wet. It dries slowly and shrinks greatly in drying, hence bricks made from it are very liable to crack before drying is completed, unless sand is added.

The bottom parts of the deposits are generally more silty, so that they are not so plastic as the top. The lower layers are, moreover, likely to contain more lime, as much of the lime may have been leached out of the upper layers by weathering. Number 691 is a typical example of a silt which was never subjected to weathering.

A material of this kind is of very little use, by itself, in the clay working industry, as the wet body being only feebly plastic is not very coherent, and shapes made from it become deformed when released from the moulds; but silt and a stiff plastic clay, when mixed together, often give better results than when either of them is worked alone.

The clays along the St. Lawrence river between Riverside and Aultsville, are, in places, quite sandy or silty in the upper part, particularly near the old brickyard site a little east of the Crysler monument, and at the shore on lot 3 of Williamsburg township, where sample 687 was collected. The upper part of the bank at this point, owing to its sandy texture, has a lower drying shrinkage than the bottom clay, the reverse of what generally occurs in these deposits; but the upper part of the deposits, at this particular locality, has been modified by the work of the river when it stood at a higher elevation and before it had cut down to its present bed.

The strip of sand which lies north of the clay bed in this locality is also a river deposit, but a good deal of sand has also been deposited on the clay, and mixed with it by the river currents.



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The top and bottom portions of the bank, when mixed, give a good brick material which does not need the addition of sand; but for tile making, a larger proportion of the bottom clay would have to be used, in order to obtain a stiffer mixture which would not deform when coming from the die of the machine, particularly when making the larger sizes of drain tile, such as 8-inch.

There is quite a large deposit of clay just north of the village of Farrans Point, where the sample 690 was procured from a cut bank 9 feet high on a small creek, representing the average of the deposit from top to bottom. This is a good brick material, as it is not so stiff working as most of the marine clay, and has a reasonable shrinkage. It appears to contain quite a percentage of lime, as the burned colour is pale, and not a good red, on account of the bleaching action which the lime exercises on the iron during firing. This clay is scarcely strong enough in the wet state to make round tile, except the smaller sizes. The two patches of stoneless clay along Doherty brook north of Dickinson's Landing, in Osnabruk township, contain brick and tile clays of a strong plastic character; but most portions of these deposits are too shallow in depth to admit working them; there are, however, quite thick beds near the Grand Trunk Railway track.

Some of the clays are more recent than the marine clays, and appear to have been washed into swampy depressions as the marine waters receded from the areas. Some of these sediments are mixed with peaty matter, consequently, are liable to bloat in burning, if the firing is done too fast. They are very pasty when wet, consequently have bad drying qualities and abnormal shrinkages, in drying and burning.

Samples 693, 697, and 699, are examples of this class of clay, but such clays are considerably improved by the addition of a liberal quantity of sand, as indicated in the table where the results of two of the clays thus treated are given next to the corresponding number without sand additions.

The clay exposed in the cut below the sluiceway at the east end of Sheik island, in the St. Lawrence river, was chosen as an example of a typical deposit of marine stoneless clay, easily accessible for sampling, but this particular locality would not serve for practical purposes.

Physical tests and chemical analyses are given from both the upper and lower part of the deposit, and these results are representative of similar material which occurs widespread in the Ottawa and St. Lawrence valley.

There are several small isolated areas of stoneless clay along the Raisin river and its branches in Glengarry county. An extensive flat occurs to the south of the Raisin river, in the township of Charlottenburg. This area is mostly covered by sand, but the sand appears to overlie a sheet of stoneless clay, because the clay is seen at the surface in some places, and also at many points under the sand along the banks of streams flowing through the area. It would be difficult to utilize the clay in some parts of this area, as the covering of sand and sandy loam is too thick. Another disadvantage of trying to work clay in low ground is, the difficulty of keeping water out of the pits.

### Gravels.

The gravel supply of the district is chiefly obtained from raised sea beaches, which are mostly situated at the 300-foot level, or, from 100 to 150 feet above the levels of the St. Lawrence river. As the portion of land which stood above what is now the 300-foot level was confined to a group of small scattered islands, where the sea water washed them, the amount of gravels formed was consequently limited to small isolated deposits.

Furthermore, these deposits, in addition to being small, are mostly situated beyond wagon haulage distance from the river, hence cannot be relied upon as an



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important source of concrete material. They are worked, however, at various points as local supplies for the maintenance of roads, and for building barn foundations.

Apparently, when the water fell below the 300-foot level, the sea was too shallow and the land too flat for any effective wave work to be accomplished, consequently the gravels are either missing or consist only of a layer generally not more than a foot in thickness, and are now obtained just below the surface soil. Notwithstanding the small amount of gravel in these thin sheets, they have been utilized at many points for road maintenance.

Many of the larger gravel deposits are limited in their usefulness, owing to the high percentage of cobble stones and boulders intermingled with the finer materials, which are too large to enter into the composition of a concrete mixture, hence the local users, in the absence of a stone crusher, are forced to reject considerable quantities of most of these deposits.

It is probable, then, that in view of the vast quantities of concrete required for the proposed works the engineers will have to rely on crushed stone derived from rock outcrops close to the river, such as those in the vicinity of Cardinal: the crushed stone being brought down in barges to the points where required. A large amount of field stone could also be assembled at mostly any chosen locality along the river front, but for short land hauls of this kind of material some points are more favourable than others.

### Sand.

The sand areas, like the marine stoneless clays, are confined to the lower elevations of the regions. In the township of Williamsburg, in Dundas county, the sand areas are close to the St. Lawrence river, on terraces standing at an elevation of 225 to 250 feet. The sands on the narrow terrace bordering the river between Farrans Point and Dickinson's Landing, in Stormont county, are from 200 to 225 feet in elevation, while the largest areas of sand in the region are those in Glengarry county, lying on plains about 175 feet above sea level.

The position of these sands and the slope of their surface seem to indicate that they were laid down by the St. Lawrence river, when it stood at a higher elevation. The sand from deposits of this nature in this district are essentially fine in texture, having an average fineness of about 80; the greater part of the grains consists of quartz, with each grain well rounded. Due to the continual washing by the river, the greater proportion of the limestone which one would naturally expect to find in sands in this district, has been removed.

The numerous beaches which have been built up by wave action on the slopes of the boulder ridges of the district, at the 300-foot level, or higher, contain quantities of sand, mixed with the larger gravel material. This could be screened to supply small amounts of sand for concrete, but could not be relied upon for large tonnage. Unlike the river terrace sands, this material has not been subjected to much erosion, hence the grains are subangular to angular. A large percentage of the grains is composed of limestone.

A few scattered deposits of glacio-fluviatile material are to be found in this district, but it is doubtful if they will furnish any considerable tonnage for concrete construction. Like the sands in the beach deposits, they are composed, for the most part, of limestone grains, but are more rounded.

A number of typical samples of sand from this district were collected and tested for concrete. The results of these tests are given in the following tables:—



Granulometric Analyses of Sands from Localities in Eastern Ontario.

Sample number.	1907	1908	1912	1913	1917	1918	1925	1928	1929	1930	1931	1932	1933
Cumulative per cent.													
Retained on 4 mesh				1.81			9.40		2.90	5.47			10.16
" 6 "				3.22			17.05		6.35	10.84			18.67
" 8 "				4.92			23.55		10.25	18.89			26.53
" 10 "				7.02			29.65		17.15	28.64			36.04
" 14 "			0.45	10.82			33.25	0.60	23.85	37.64		1.05	44.05
" 20 "			1.06	20.97	0.15		38.45	1.30	34.15	45.09		1.45	53.20
" 28 "	0.40		1.81	42.53	0.35		44.20	1.95	47.50	53.94		2.15	62.81
" 35 "	0.90	0.35	5.81	67.83	1.00	0.10	54.61	9.35	62.20	64.87	0.45	7.45	77.41
" 48 "	5.50	1.43	18.11	83.26	2.66	1.10	69.96	22.25	76.86	76.57	5.31	29.50	88.36
" 65 "	29.95	30.60	43.76	89.41	7.26	16.10	84.26	51.10	86.61	85.72	30.42	56.65	93.06
" 100 "	77.56	74.91	74.01	92.95	38.26	63.68	93.52	87.09	93.16	93.02	68.68	79.50	95.06
" 150 "	88.32	87.51	81.94	93.80	61.16	76.12	95.37	93.97	95.91	94.77	78.19	85.85	95.51
" 200 "	98.03	97.11	93.34	94.20	93.21	91.76	96.88	98.81	97.86	97.39	91.50	94.35	96.31
Average fineness.	73.93	74.79	76.08	36.22	107.56	90.80	34.60	59.99	33.65	32.33	84.64	67.33	25.91
Character of sand	a	a	a	b	a	a	b	a	c	c	c	c	b

a. Terrace sand.  
b. Beach sand.  
c. Glacio-fluvialite.







## SESSIONAL PAPER No. 26a

## DESCRIPTION OF SAND SAMPLES.

*Sample No. 1907.*—Locality: south half lot 37, concession I, township Osnabruk, Stormont county.

This sample was taken from drillings with post hole auger, through 6 feet of sand, from top to bottom of dune.

*Sample No. 1908.*—Locality: lot 7, concession I, township Williamsburg, Dundas county.

Taken from drillings from post hole auger, from top to bottom of dune, 8 feet in depth.

*Sample No. 1913.*—Locality: lot 23, concession VIII, township Cornwall, Stormont county.

A prominent boulder ridge running N.E. and S.W. is flanked on the N.W. by a steep pitching beach ridge. A pit has been opened up on this beach, and a small amount of gravel was obtained. To the southwestern part of the pit, about 4 feet of sand has been exposed, nicely stratified, and covered by about 2½ feet of gravelly till. The bottom of the sand was not exposed, nor was its continuation to the southwest determined, as it was covered. The sample was taken vertically down the face of the exposed layers.

*Sample No. 1917.*—Locality: lot 22, concession I, township Williamsburg, Dundas county.

Sample taken from borings from auger drill in dunes to southwest corner of cemetery. The sand was of uniform texture throughout the whole 8 feet drilled.

*Sample No. 1918.*—Locality: lot No. 15, concession I, township Osnabruk, Stormont county.

Sample taken from bank of St. Lawrence river from 12-foot section of sand overlying clay. The top 3 feet of the sand was iron stained, and reddish in colour, below which, for 7 feet, a clean, greyish sand was obtained. The bottom 2 feet was slightly clayey.

*Sample No. 1925.*—Locality: lot No. 23, concession I, N.S.R., township Charlottenburg, Glengarry county.

Sand and gravel pit owned by Frank Lefevre. This is a well developed beach ridge, built upon the western end of a boulder ridge. Stratification is well marked wherever a face is exposed, and shells are abundant throughout. The sample was taken from a loaded rig, which was drawing material for concrete from this pit.

*Sample No. 1928.*—Locality: lot No. 6, concession I, township Osnabruk, Stormont county.

Sample taken from sand pit opened on east side of road opposite cemetery. The sand contains numerous shells.

*Samples Nos. 1929-1930-1931-1932.*—Locality: north half lot 5, concession IV, N.S.R., township Charlottenburg, Glengarry county.

This deposit is probably of glacio-fluviatile origin, and is composed of sand and gravel, covered in places with a thin layer, 12 inches thick, of beach material carrying shells. No shells were to be found in the material sampled. Four samples were taken from different parts of this pit to represent four different grades of material. No. 1929—Fine gravel with sand; No. 1930—Coarse gravel with sand; No. 1931—Fine sand; No. 1932—Coarse sand.

*Sample No. 1933.*—Locality: lot 6, concession VIII, township Charlottenburg, Glengarry county.



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There is a pit opened on this property on a ridge of considerable extent. It rises fully 40 feet above the gully. Shells are abundant, and there are considerable quantities of coarse material. General sample taken.

#### EXPLANATION OF PHYSICAL TESTS ON SANDS.

The samples of sand tested, averaged about 20 pounds in weight. These were passed through the 3-mesh screen, and the material retained on this screen was called gravel, while that passing through was called sand. The results of the tests tabulated in the accompanying tables were obtained from the material passing through the 3-mesh screen.

#### GRANULOMETRIC ANALYSIS.

In all cases, 100 grams of the sand to be tested, was employed. The results obtained from this test give one an idea of the texture of the sand with regard to the size of grain. The test was carried out as follows:—

The 100-gram sample was placed on the coarsest screen, which was nested on the next size finer, and so on down to the 200 mesh, with retaining pan on bottom. The nest of screens was then thoroughly shaken on a mechanical shaker for 10 minutes: the material retained on each screen being collected, weighed, and noted. The sample, in the first place, being 100 grams, the weight recorded as retained on each screen is the percentage retained on that screen and passing through the next size larger; and the cumulative percentage, or the percentage of all material that would be retained on any given screen, if that screen alone were employed, can readily be determined by totalling the weights retained on all coarser screens.

The results obtained in these tests are tabulated as cumulative percentages in the accompanying table.

To gain an idea of the fineness of the grain of the sand, and to be able to express this in one figure for purposes of comparison, the average fineness of each sample was calculated. This was determined as follows: The quantity of material passing through each screen and retained on the next smaller is multiplied by the mesh of the screen passed through. The results thus obtained are totalled, and divided by 100, the final result being the average fineness. In other words, if all the grains of the sample were brought to an average size, they would just pass through a screen whose mesh was equal to the average fineness of the sample.

#### PERCENTAGE OF SILT AND CLAY.

The percentage of silt and clay was determined by the elutriation method; 100 grams of sand being used in each case. The weighed sample of sand was placed in a glass vessel and subjected to a rising current of water of constant head which carried off the silt and clay. While the water being siphoned off was clear, the material remaining in the vessel was dried to constant weight and weighed, and the percentage of silt and clay calculated.

#### SPECIFIC GRAVITY.

The specific gravity was determined by means of a Le Chatelier specific gravity flask. The bulk of the flask was filled with water, and the height of the column of water read on the graduated stem. Fifty grams of sand were admitted, care being taken to permit the escape of the air; and the new height of the water column read. The difference in the two readings gave the volume of water displaced by 50 grams of sand. From this data the specific gravity of the sand was computed.



## SESSIONAL PAPER No. 26a

## WEIGHT PER CUBIC FOOT AND PERCENTAGE OF VOIDS.

The weight per cubic foot, and the percentage of voids, was calculated from the weight of 500 c.c. of sand. The method of obtaining the weight of 500 c.c. of sand was as follows:—Two brass cylinders were used, one having a volume of exactly 500 c.c. and the other with an outside diameter slightly smaller than the inside diameter of the first one, but twice as long. The longer cylinder is filled with sand, and the 500 c.c. cylinder is inverted over the top of it. The two cylinders are then inverted and the long cylinder withdrawn leaving the sand in the graduated cylinder. The sand was then struck off level, and the amount of sand in the 500 c.c. cylinder weighed. The weight per cubic foot when calculated will probably be lower than when other methods are employed for compacting the sand in the 500 c.c. cylinders; but it was found that the results obtained on the same sand, when this method was used, were so uniform, even when different operators performed the test, that it was thought advisable to adopt it.

The percentage of voids calculated from the weight obtained by the above method will also, for the same reason, be higher than when other methods are employed.

## TENSILE STRENGTH.

The tensile test was made in the usual manner on briquettes similar to those used in standard cement testing, using a 1:3 mixture. Three briquettes were broken at 7 days and three at 28 days, and compared with briquettes made of the same cement and standard Ottawa sand.

## COMPRESSIVE STRENGTH.

The compressive tests were made on mixes of 1:3 mortar, using the same cement with the different sands to be tested. Cylinders 2" by 4" were employed and breaks were made at 7 and 28 days, and compared with standard cylinders, run concurrently.

An examination of the tabulated results of all these tests shows that the finer sands make poor concrete material. As a general rule, if there is no organic matter present, and the percentage of silt and clay is low, a sand which has 75 per cent retained on the 48 mesh will make a good concrete: one that would be safe to employ, with a coarse aggregate, for concrete work. A good sand should have a strength at least equal to the standard, at both 7 and 28 days.

## CONCLUSIONS.

There are three sources of sand in this district, namely from (1) River terrace and dune sands; (2) Sand from beach deposits; (3) Glacio-fluviatile sand.

1. *River Terrace and Dune Sands.*—These are mostly very fine in texture and contain appreciable quantities of silt and clay. They are totally unsuited for use in structural work.

2. *Sand from Beach Deposits.*—There are numerous beach deposits built by wave action on the slopes of some of the morainic ridges which occur in this region. These are generally small in extent and could not be depended on to furnish any considerable quantities for concrete. These beaches generally contain a large proportion of coarse material and the texture of any one beach will vary in different parts. As a rule the sand from a deposit of this nature will make a good concrete mixture. Good examples of this class of deposit are Samples No. 1913 and No. 1925.

3. *Glacio-fluviatile Sand.*—Glacio-fluviatile deposits of sand and gravel are to be found in a few places in this district. The coarser material found in these deposits make a good grade of concrete and the finer sand would also be suitable for concrete



when mixed with a coarser aggregate. The deposits are of small extent, however, and cannot be counted on for any large tonnage.

Bed-rock.

An earthy mantle of unconsolidated glacial drift, varying from a few feet to 150 feet thick, covers the bed-rock almost everywhere in the region.

The St. Lawrence river has not quite succeeded in cutting down through this cover so that no outcrops of rock are visible on its banks in Dundas, Stormont, or Glengarry counties. In a few portions of the channel, however, an occasional patch, which stands at a higher level than the rest of the bed-rock bottom, is being scoured by the water; but everywhere else the river is flowing over clay, sand, or gravel.

A good deal of information regarding the position and character of the bed-rock under the river channel, was obtained during the last two years by means of the series of diamond drill borings made by the Hydro-Electric Power Commission of Ontario, between Morrisburg and the New York state shore of the river.

Similar information has been obtained from borings made by the engineers of the Department of Railways and Canals, and of private companies, in other parts of the river channel.

The chief information regarding the character of the bed-rock on land was obtained from small scattered outcrops, where quarries had been opened in past years to supply building stone.

Although the amount of bed-rock accessible for inspection is meagre, certain generalizations can be made regarding its character as a whole.

The rocks of this portion of the St. Lawrence valley are made up entirely of nearly flat lying beds of more or less pure limestones, magnesian limestones, dolomites, shaly limestones, and a minor amount of shale. In age they include four subdivisions of the Ordovician rocks, viz., Beekmantown, Chazy, Black River, and Trenton.

The lowest formation, the Beekmantown, is not exposed at the surface within the area, but borings made by the Hydro-Electric Power Commission in the bed of the St. Lawrence river at Morrisburg, to a depth of 40 feet in bed-rock, seem to have pierced these rocks. They consist of dense grey magnesian limestones, with a very small amount of black shale. An inspection of some 45 drill cores from this locality shows that a typical section is as follows:—

BORE-HOLE No. 10.

Depth.				Description.	Thickness.	
ft.	in.	ft.	in.		ft.	in.
0	0 to	2	3	Coarse grained, dark grey limestone, crystalline in texture (probably magnesian) . . . . .	2	3
2	3 "	5	0	Dark grey, fine to medium grained magnesium limestone . . . . .	2	9
5	0 "	7	0	Fine grained, grey, magnesium limestone . . . . .	2	0
7	0 "	9	6	Fine grained, dark grey, shaly limestone . . . . .	2	6
9	6 "	10	0	Fine grained, grey limestone . . . . .	0	6
10	0 "	13	3	Dark grey, shaly limestone . . . . .	3	0
13	3 "	15	0	Fine to medium grained, compact grey limestone (probably dolomitic) . . . . .	2	0
15	0 "	16	0	Dark grey to black shale . . . . .	1	0
16	0 "	20	0	Compact, fine grained, grey limestone . . . . .	4	0
20	0 "	22	6	Fine grained, flinty, light grey limestone . . . . .	2	6
22	6 "	26	0	Fine grained, dark grey, shaly limestone . . . . .	3	6
26	0 "	27	0	Fine grained, dark grey, compact limestone . . . . .	1	0
27	0 "	30	0	Fine grained, dark grey, shaly limestone . . . . .	3	0
30	0 "	31	6	Fine grained, dark grey limestone with calcite and pyrite seams, (probably dolomitic) . . . . .	1	6
31	6 "	35	0	Dense, fine, grey limestone . . . . .	3	6
35	0 "	37	7	Medium grained, grey limestone with secondary calcite, mottled with dark grey patches (many small cavities) . . . . .	2	7
37	7 "	37	9	Black shale band . . . . .	0	2
37	9 "	39	7	Medium grained, grey limestone with secondary calcite, mottled with dark grey patches . . . . .	1	10
39	7 "	40	0	Dark grey, fine grained, magnesian limestone . . . . .	0	5



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It should be noted that the variation in the chemical composition of the rock does not affect its physical character, for dolomites are often to be preferred to limestones for certain classes of structural work.

The dark shales are slaty in character, hence do not slake in water even when crushed and ground. A clay shale slakes readily, and becomes plastic under this treatment.

The sections of these rocks obtained in the drill cores show no defects from an engineering standpoint.

There is no trace of weathering—the top of all the cores being just as fresh and unweathered as the bottom.

There are no open seams or cracks, neither vertical nor horizontal. Each bed or layer of rock is solidly welded to the one above and below it. The vertical joint planes are tight and impervious.

There is very little siliceous material present, consequently there are no sandstone beds or layers which might prove to be porous, but not necessarily so.

The Chazy, the next formation in ascending order, is nowhere exposed in the region so far examined, but, according to Dr. Ells, is present at depth.

The Black River formation overlies the Chazy. A typical outcrop of this formation is to be found three-fourths of a mile east of Bouckshill, lot 21, concession V, township Williamsburg, Dundas county, Ont. These rocks consist of dark grey to grey, compact, fine grained limestones generally carrying numerous fossils. The beds are usually of sufficient thickness to enable large blocks to be quarried for building purposes.

The Trenton formation can be seen in several outcrops in the area so far investigated; a good example of this formation being exposed at the Mille Roches quarries. From these quarries great quantities of large dimensioned pieces have been excavated in past years for canal construction. This formation consists mostly of fine grained limestone, dark in colour, with numerous small fossils scattered through the rock. Exposed to the weather, it turns much lighter in colour, and gradually exhibits wavy disintegration along the planes of bedding. This characteristic can be plainly seen in the blocks which are lying around the abandoned quarries.

In the territory so far examined, there are several localities where building stone could be obtained in sufficient quantities for use in large construction work, but not always convenient to rail or water transportation.

The data obtained so far do not give any indication of a deep pre-glacial channel buried beneath the glacial drift in the St. Lawrence valley.

## VII.

## POTTERY CLAYS.

MARY ETTA YOUNG.

The chief material used by the potter is clay. Its characteristic quality—plasticity—enables the wet clay to be moulded into any desired form and to retain this form when dried and during burning. In most of the methods used in making art pottery, it is necessary to use a highly plastic clay, smooth in texture.

Practically all of the clays used in modelling by sculptors and art students in Canada, are imported either from the United States or England. They are of the stoneware type, being highly plastic and smooth, and much cleaner to manipulate than the common brick or tile clays. We have similar clays available in Nova Scotia



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and Saskatchewan, Canada; but none are known to occur in the other provinces, within the present range of transportation facilities. All clays require a certain amount of preparation after mining, before they can be sold for use to art schools, sculptors, or studio potteries; but there are no firms engaged in mining, preparing and selling clays for these purposes in Canada.

Many of the clays tested at the Mines Branch Laboratory show sufficient plasticity and smoothness to indicate that they might serve as modelling clays: such as those used in our technical schools, or as pottery clays. Especially is this true of the above-mentioned clays from Saskatchewan and Nova Scotia.

A clay to be tested as to its suitability for the manufacture of pottery, first undergoes the regular tests as to shrinkage, drying, range of fire, and burned colour. Its behaviour on the wheel, for casting, and for building, then remains to be determined.

For making pottery by the casting process, the clay is mixed with an excess of water, and run through a 60-mesh screen. It is then known as a slip. This slip is allowed to stand for a day, then the excess water is siphoned off. Part of the slip is set aside to be used for casting, while the remainder is poured into plaster dishes, and left there until enough water has been absorbed by the plaster to bring the clay to the proper consistency for wheelwork and building.

The casting slip is brought to the consistency of cream, and is then poured into a plaster pottery mould, and allowed to stand a few minutes, after which, all that can run is poured out. The remainder—which adheres to the mould in an even layer—shrinks away from the mould surface on drying, and is easily removed. The cast piece is then smoothed and finished by hand. This casting process is used to a large extent in commercial work.

The clay may then be tried out on the wheel; and also as to its adaptability for built ware. Pieces made by these methods are allowed to dry, and, together with the cast ware, are fired to a temperature ranging from 1,880 to 1,990 degrees Fahr. (Cone 06 to cone 03). The fired pieces of pottery before being glazed are known as biscuit ware.

Tiles may be made by pressing ground, semi-dry clay into steel moulds, either by machinery or by pressing the clay while in the plastic state, into plaster moulds. Tiles made from clay only, nearly always show a tendency to warp in drying; to obviate which, ground calcined clay or sand is added to the clay.

The biscuit pieces that are cracked or warped are rejected, and perfect pieces are glazed and refired. When the glaze is examined, it is usually found to be crazed or cracked on many of the pieces.

Most clays require the addition of a non-plastic material, such as finely ground feldspar or quartz, before they can be made up into a satisfactory earthenware body that can be properly glazed. Therefore, a clay which promises to prove suitable for pottery work, is further tested by adding to it various proportions of feldspar, or flint, until the most desirable mixture or body is attained.

Flint is the common name that potters give to finely pulverized quartz, no matter whether it is produced from true flint or white sand.

The test pieces made from the above mixes are fired and afterwards glazed with a raw transparent glaze. It will be found, almost invariably, that the glazed pieces containing nearly all clay, those containing clay and feldspar alone, and those containing a large amount of feldspar, will be crazed. From such tests it is possible to determine the proper proportions of feldspar and flint it is necessary to add to the clay.

### Glazes and Enamels.

The terms "glaze" and "enamel" are often used to signify the same thing. Strictly speaking, however, a glaze is transparent, and will show the colour of the body beneath. Enamels, often called majolica glazes, are opaque, and conceal the character of the body to which they are applied.



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As pointed out above, the character of the body materially affects the behaviour of the glaze. In addition to crazing or cracking, the glaze may develop bubbles or blisters, or may shiver or crawl during firing. The crawling is due to excessively fine grinding of the glaze, or to an excess of clay; but the other troubles are seldom due to the glaze itself and can usually be remedied by modifications of the body, and proper attention to the firing.

## TRANSPARENT GLAZES.

The clear, transparent glaze used on trial pieces in the Ceramic Laboratory of the Mines Branch has the following composition:—

White lead.. . . . .	168 parts.
Whiting.. . . . .	25 "
Feldspar.. . . . .	56 "
Kaolin.. . . . .	13 "
Flint.. . . . .	36 "

These ingredients, carefully weighed, are ground wet in a ball mill for 2 hours, then sieved through a 150 mesh, and brought to the consistency of a thick cream. The piece to be glazed is soaked to saturation in water, and then dipped into the glaze. When it is found difficult to obtain an even coat of glaze by dipping the glaze is sprayed on. The glazed piece is then fired in an oil kiln to about 1,900 degrees Fahr.

For coloured, transparent glazes, blue tones are secured by the addition of a small quantity of cobalt oxide to the above ingredients, before grinding. For greens, copper oxide is used; and for browns, iron oxide. Combinations of two or more of these metallic oxides added to the clear glaze will give a further range of colours: many beautiful effects can be obtained by such mixtures.

## OPAQUE GLAZES OR ENAMELS.

Tin oxide added to a transparent glaze gives an opaque glaze of corresponding colour. These glazes are called tin enamels. A very pleasing shade of blue, to be fired at 1,950 degrees Fahr., has the following composition:—

White lead.. . . . .	155 parts.
Whiting.. . . . .	15 "
Feldspar.. . . . .	97 "
China-clay.. . . . .	2 "
Flint.. . . . .	30 "
Tin oxide.. . . . .	74 "
Cobalt oxide.. . . . .	4 "

## MATT GLAZES.

The matt, or dull glazes, are produced by an excess of alumina or silica in the glaze. The alumina matt is the more easily handled glaze, and is produced by increasing the clay content and decreasing the flint in a clear glaze formula. Matt glazes require less grinding than the transparent glazes, and a thicker coat of glaze must be applied to the biscuit ware.

## COLOUR DECORATION.

Two methods of decorating pottery with coloured patterns are (1) underglaze, and (2) overglaze.

The underglaze colours are applied to either the unburned or biscuit ware, and the colour is burned on. A coat of clear glaze is then applied, and the ware given a final firing. Underglaze decoration is a true ceramic method of decoration, since, after the final firing, the body, colour, and glaze are fused together. In underglazing, firing takes place at high temperatures, ranging from 1,800 to 2,500 degrees Fahr., and taking anywhere from 6 hours to 6 days to accomplish.



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In overglaze work the decoration is applied to a piece already glazed. The colour, in this case, requires to be fixed by firing; but the temperature used in overglaze firing is much lower than for underglaze.

In ordinary china painting, the colours are applied to a piece that has been commercially glazed, hence they only require to be fixed at a low red heat, which is attained by about two hours' firing.

#### TYPES OF POTTERY.

Art pottery includes the low fired buff, or red burning ware, as well as the high fired white, translucent porcelains. Perhaps the finest type of pottery being made from a ceramic point of view is the porcelain manufactured in Copenhagen, Denmark.

Porcelain is made from a combination of china-clay, feldspar, and flint. It is biscuited at a low fire, then glazed, and refired at a high temperature.

The only deposit of china-clay known to occur in Canada is found at St. Remi, Quebec. It is high grade, and compares favourably in colour and texture with the standard brands on the market; although its shrinkage on burning is rather high. A great deal of the feldspar used in the United States potteries is imported from the provinces of Ontario and Quebec.

Much art pottery, however, is made of stoneware clay. This burns to a very hard, opaque body, which may be white, buff, or grey. Both body and glaze are fired to a temperature of 2,400 degrees Fahr., approximately. The Rookwood and Fulpar potteries in the United States and the Ruskin pottery of England are of this type.

Earthenware and majolica wares have a soft, porous, opaque body, and the colour varies from a deep cream to buff and red. From an art standpoint, this ware may be quite as good as the most expensive porcelain. The ware is glazed with a coloured transparent glaze or an enamel. Some of the clays tested in the Mines Branch could be used for the manufacture of wares of this type.

All the art pottery sold in Canada, at the present time, is imported, principally from England, Japan, and the United States. Small industries of this kind should prove profitable at points where suitable clays occur, and where there is a considerable tourist trade.

#### British Columbia.

*Chimney Creek, Cariboo.*—White residual clay from this locality, when washed and screened, makes a good casting body; but shrinkage is excessive. It fires to a dense, cream coloured body at cone 03, which takes a glaze well; and no crazing is developed on glazed pieces. This clay would form the basis for a pottery body, but a certain amount of flint and feldspar should be added to reduce the shrinkage, and a white burning plastic clay, such as that which occurs at Quesnel, should be added in order to improve its working qualities.

*Terrace and Lakelse.*—Extensive deposits of surface clay are said to occur in these localities. Their suitability for brick and tile has already been referred to in this report. Inasmuch as they are smooth and plastic in the raw state, their use is suggested for flower pots, and for ornamental pottery. These clays work well either on the wheel, or for casting, and their drying qualities are good, and shrinkage low. Specimens of pottery made from them, burned to a dense red body at 1,750 to 1,800 degrees Fahr. The pieces glazed with coloured tin enamels had good texture, and little or no crazing was developed. The glazed pieces were burned to the softening point of cone 06.

#### Alberta.

The best pottery clays in the province of Alberta occur on the Athabaska river and its tributaries north of Fort McMurray. They are buff and grey burning clays.



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of the stoneware type, found in association with the tar sands. One of the samples tested for pottery was found to be an excellent wheel clay, but made a very poor casting slip. It had good drying qualities, and when fired to cone 05, had a good hard body, of dark buff colour. The ware made from it was easily glazed with either enamels or transparent glazes, and no faults whatever developed.

## Saskatchewan.

*Willows.*—A considerable amount of clay was excavated at Willows, and sent to the sewer pipe works at Medicine Hat. The run of bank at this point, when washed and screened, makes a good pottery clay for either the wheel or for casting. It is very plastic and smooth, and dries without difficulty. When burned to cone 03, the body is hard, and nearly white in colour. The glazed pieces showed slight crazing; but if the body were burned to a higher temperature before glazing the crazing would probably be overcome. This would make a good modelling clay for school use.

*East End.*—Two samples of clay from this locality, were tested; one, a white washed clay used by the Medalta Pottery Company at Medicine Hat, the other a dark grey clay, which occurs in the bank worked by the pottery company.

The white clay was made up into three separate casting slips as follows:—

- A. Clay alone.
- B. 75 clay  
22 flint.  
3 whiting.
- C. 55 clay  
40 flint  
5 whiting.

All the mixtures made good cast ware. The object of using the whiting was to offset the effect of the flint, which tends to make the body too porous and soft when burned at low temperatures.

The trial pieces were biscuitied at cone 04 (1070° C.). The burned tests ranged from A, which had a dense body of deep cream colour, to C, which was lighter in colour and more porous. These tests were glazed with a transparent green glaze, also with commercial glazes from Wengers, England.

No crazing or other glaze faults developed in these glazes.

The dark grey clay occurring at East End, was washed and screened at the laboratory, and made up into the following body:—

- 55 clay
- 40 flint
- 5 whiting.

This mixture burned to a very porous body, of pale cream colour, at cone 04. It requires a higher fire, and the addition of so much flint is not necessary.

Both clays made excellent wheel bodies, and are glazed without difficulty. Glazed samples were sent to the museum at Regina, and also to the office of the Bureau of Labour and Industry.

## Ontario.

Ordinary brick clays occurring at Kingston, Arnprior, Cobden, and Renfrew, were tested; but they were short grained, and had poor working qualities. Bowls were thrown on the wheel from these clays, but they developed cracks on drying, and had to be discarded.

*Toronto.*—The interglacial clay used by the Don Valley Brick Company for making red stock brick was tried out on the wheel, and its working qualities were found to be fairly good. The pieces had good drying qualities, and low shrinkage.



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Burned at cone 05, the body was porous, and of light red colour. Very good results were obtained on this clay with the use of coloured tin enamels. The clay also made a good casting body.

A large deposit of similar clay occurs at Greenwood avenue, north of Gerrard street, where several brickyards are in operation. The clay was used on the wheel just as it came from the bank; but it was washed for the casting slip.

*Hamilton.*—A fairly plastic, coarse grained clay, occurring at Waterdown, is used for making sewer pipe. As it is rather gritty it is better to wash and screen it through a 60 mesh screen before using for a pottery body. The working and drying qualities of the washed clay were good. It is easily overfired, and at cone 05, the body is dense, and of dark red colour. The glaze developed only a slight craze.

A rather calcareous glacial clay from Bartonville burns to a buff body at cone 05. Owing to the presence of pebbles and coarse grit, this clay must be washed and screened before using. The washed clay is excellent for throwing on the wheel, also for modelling. Good effects were obtained on this clay with the use of coloured enamels; but as the body is porous, like all clays with a high lime content, the glazing must be applied thickly.

Up to the present time, no china-clay or stoneware clays have been found in southern Ontario; but attractive pottery could be made from the low fire, red burning clays which occur in many parts of the province. Mixtures of the buff and red burning brick clays could also be used to advantage in some cases. Nearly all these clays, however, should be washed and screened for use in pottery making, or for instruction in the manual arts in schools.

### Quebec.

*St. Rémi.*—A yellow, plastic clay occurs at St. Rémi d'Amherst, where it is mixed with the white china-clay. This clay makes a good casting slip, and works well on the wheel, but the burned body is very porous, and the glazed ware is badly crazed. A mixture of red stoneware clay from Nova Scotia and the St. Rémi clay, in the proportions of red clay 20, flint 20, and yellow St. Rémi 60, gave much better results. In order to obtain a proper density, this body should be burned to a much higher temperature than that to which the trial pieces were subjected.

*Buckingham.*—A common, red burning, brick clay was tried out on the wheel. This clay had only average working qualities, with low shrinkage, and good drying property. A wheel piece was fired at cone 05, and glazed with a green, tin enamel. The glazed piece is a splendid example of the good results that may be obtained from some of the ordinary red burning clays.

### Nova Scotia.

*Avonport.*—A red brick clay occurring at Shaw's brickyard at Avonport, makes a good wheel clay. At cone 06, it burns to a hard, red coloured body. It was used just as it came from the bank without any preparation except grinding. It can also be used for making cast or built ware. The glaze effects obtained on this clay were excellent.

Similar clay occurs at Middleton, Bridgetown, and Annapolis.

*Albert Mines.*—This is a highly plastic clay, which occurs in the swamp near the railroad track. It makes a good wheel clay. It dries slowly, and has a high shrinkage. The glaze on this ware has a tendency to bubble, and the clay should have a small amount of barium carbonate (.05 per cent) added before using. It burns to a fine red colour, at cone 06, and excellent effects were obtained by coating with transparent glazes or opaque enamels.

Stoneware clays occur in Nova Scotia at Middle Musquodoboit and Shubenacadie. The clay from Middle Musquodoboit is mined and shipped to St. John, N.B. by Messrs. Foley Bros., where it is manufactured into stoneware domestic pottery. This clay is



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also mined and sold by the company, and is the only Canadian clay of this type on the market.

*Shubenacadie*.—Both sandy and plastic clays occur at Shubenacadie, which are shipped to Sydney Mines for the manufacture of fire brick. The plastic clay makes an excellent body for pottery, either made on the wheel, cast, or built. It is the best clay for this purpose in the province.

*Musquodoboit*.—The Musquodoboit clay is very plastic and smooth, and works well on the wheel, and for casting. The body, however, is difficult to glaze, the glaze having a strong tendency to craze.

Three series of 21 trials were made and fired with the following results. The pink clay was obtained from the Foley pit and the red clay from Norman Deals property.<sup>1</sup>

	Red clay.	Pink clay.	
	Cone 02, raw transparent glaze.	Cone 02, tin enamel.	Cone 04, raw transparent glaze.
50 clay.....			
50 feldspar.....	crazed.....	crazed.	crazed.
50 clay.....			
40 feldspar.....	slight craze	crazed.	crazed.
10 flint ..			
60 clay			
40 feldspar .....	crazed.	crazed.	crazed.
50 clay.....			
30 feldspar.....	good	crazed.	crazed.
20 flint.....			
60 clay.			
30 feldspar.....	good	crazed.	crazed.
10 flint.			
70 clay.....			
30 feldspar.....	good.	crazed.	crazed.
50 clay.			
20 feldspar.	good.	good...	crazed.
30 flint.....			
60 clay.....			
20 feldspar.....	good.	good...	crazed.
20 flint.....			
70 clay.....			
20 feldspar.....	good.	crazed.	crazed.
10 flint.....			
80 clay.....			
20 feldspar.....	slight craze	crazed.	crazed.
50 clay.			
10 feldspar .....	good	good ..	crazed.
40 flint .....			
60 clay .....			
10 feldspar.	good.	good..	crazed.
30 flint. ....			
70 clay.....			
10 feldspar....	good.	crazed.	crazed.
20 flint. ....			
80 clay.....			
10 feldspar. ....	good	crazed.	crazed.
10 flint.....			
90 clay.....			
10 feldspar.	crazed.	crazed.	crazed.
50 clay ..			
50 flint. ....	good.	good...	crazed.
60 clay. ....			
40 flint. ....	good.	good..	crazed.
70 clay.....			
30 flint. ....	good.	good..	crazed.
80 clay.....			
20 flint.....	good.	good...	crazed.
90 clay .....			
10 flint.	slightly crazed.	crazed.	crazed.
100 clay.....	crazed.	crazed.	crazed.

<sup>1</sup> "The Clay and Shale Deposits of Nova Scotia and Portions of New Brunswick," Geological Survey Branch, Department of Mines, Canada, by H. Ries and J. Keele, Memoir No. 16-E, pp. 73-83.



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The clay from Middle Musquodoboit was used in 1919 and 1920 in the public schools of Ottawa, for instruction in the sixth grade manual arts work. It was found to be an excellent clay for this purpose, and a splendid exhibit of pupils' work in pottery is the result.

### **Prince Edward Island.**

A red clay, occurring at Richmond, Prince Edward Island, is exceptionally smooth and plastic, and makes an excellent clay for built ware. It also works well on the wheel, and for casting. It has good drying and firing qualities. At cone 06, it has a hard, dense body of beautiful red colour, which does not require glazing. The ware, however, takes a good glaze, and an artistic ware is obtained by using coloured transparent glazes. This clay is well adapted for school work, and is in fact one of the best red burning clays so far found in Canada.



## ROAD MATERIALS DIVISION.

K. A. CLARK, *Chief of Division.*

The investigational work on road materials during the year has been a continuation of examinations already commenced. Some time was spent in Manitoba, rounding out what was done in that Province the previous year. The balance of the season was given to an examination of materials along some of the roads in Rocky Mountains Park, Alta. This more detailed work followed naturally after the general survey, in 1918, of conditions throughout the mountainous country in Alberta and British Columbia.

Road material surveys in Ontario were continued. Mr. Picher finished another stretch of the Toronto-Montreal route; and Mr. Gauthier carried on a miscellaneous programme of surveying and sampling. A summary report of their work appears as part of the following general report of the Division.

## I.

## ROAD MATERIALS AND SOIL CONDITIONS IN THE AREA BETWEEN WINNIPEG AND BRANDON, MAN.

Materials and soil conditions encountered along the highway between Winnipeg and Brandon were examined in 1918. This year, time enough was spent in extending the survey over an area approximately six townships wide, from north to south; with the Winnipeg-Brandon route cutting through the centre of the area. The 1918 work indicated that the main problem facing the Road Materials Division in undertaking investigations in areas such as this one, was an adequate examination and study of the soil conditions in their relation to road building, so as to lend some light on the question of how a serviceable rural road can be provided under the various typical soil conditions that occur. The soil changes have consequently been blocked out in a very general way. These soil areas, as well as occurrences of gravel, are presented in a graphic way by means of the accompanying sketch map.

The area in question forms a cross section across the bed of the ancient Lake Agassiz.<sup>1</sup> The highest western shore of Lake Agassiz is at Brandon, extending south-east to the Tiger hills, and northeast to the Riding mountains. The Assiniboine river entered the lake at the present site of Brandon, and threw out in front of its mouth a huge delta accumulation, extending east to the neighbourhood of Portage la Prairie, and northeast to near Gladstone. The soil of the country to the west of this highest shore line is the direct product of the glacial till deposited in glacial times. The soil to the east, however, has suffered all degrees of modification, due to factors introduced by the ancient lake and by the Assiniboine river.

The Assiniboine river, emptying into Lake Agassiz, deposited an accumulation of coarse material in the form of gravel in the neighbourhood of the present site of Brandon; then fine material was spread out over a wide area. From Brandon, eastward, to near Austin, southeastward along the Assiniboine river almost to Portage and northeast to the line of the beach line running through Edrans and Arden, this

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<sup>1</sup> Glacial lake, Agassiz, W. Upham, Geological Survey of Canada, 1890.



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delta country is hilly, consisting of a fine silty soil and sand. The waste sand areas and dunes seem to be due to a certain extent at least, to the re-sorting and distribution of the silt and sand constituents in the delta deposit by wind action. Proceeding eastward, the hilly country gives place to the plain in which the soil continues light and sandy, but gradually shading off into the clay land of the Portage plains.

Lake Agassiz, in its retreat, left many beach lines behind it. Upham spent much time in locating and tracing them out. A few of them can be seen in the area now being considered. Since, when well developed, they contain gravel or sand, the beaches are of significance from the road material standpoint. They appear as a slight swell on the flat landscape, somewhat like a railway grade winding away in the distance. Two such beaches occur in the delta area. One, named by Upham the Norcross beach, runs north from Neepawa. Another runs along the edge of the hilly country south from Arden, through Edrans, crossing the Canadian Pacific railway between Sidney and Austin, and losing itself in the hills to the south. Still another beach, called the Burnside beach, runs from northwest to southeast, both north and south of the Assiniboine river, and a short distance west of Portage. This beach line has been made the dividing line between the delta area and the clay area to the east. The Kinosota ridge is a continuation of the Burnside beach. The connexion cannot be followed through the intervening swampy area.

East of the delta area is a stretch of country in which the clay constituent of the soil predominates. This clay constituent is apparently the gumbo clay of the Red River valley. In the Portage plains, and eastward north of the Assiniboine toward Stonewall, the soil has a high silt and sand content. Boulders occur scattered about also. The soil may be a modified glacial till. But in any case, the clay constituent is there, and imposes its characteristics all through this area. Along the north bank of the Assiniboine and in the country to the south, the land gets more and more clayey as the Red river is approached, and becomes the real "gumbo" country. The clay extends east of the Red river for about twenty-five miles, becoming more sandy, however, until the flat clay prairie is left, and light soil conditions commence.

A tongue of country extends from the light area east of Winnipeg, southwestward along the Red river, and toward the city. This area is decidedly sandy, and ends in a series of eskers which give the deposits of gravel such as that at Bird's hill.

A fragmentary beach line—called the Ossowa beach by Upham—occurs running northeast from a short distance north of Poplar point, and skirts the southern limit of a rough, stony, little settled region.

Two small gravel deposits<sup>1</sup> occur in the clay land north of the Assiniboine river, one north of the post office of St. François Xavier, the other northwest of Pigeon lake.

The only occurrences of bed-rock are at Stonewall and Stony Mountain. A soft magnesian limestone is quarried at these points. Similar limestone also occurs in the neighbourhood of Garson on the eastern limit of the area examined.

The accompanying map shows the soil areas and the occurrences of material mentioned. The limits set for the soil areas are not exact since no exact limits exist. The soil types grade into each other.

#### CHARACTERISTICS AND PHYSICAL PROPERTIES OF THE SOIL TYPES.

*Glacial till west of Brandon and the upper shoreline of Lake Agassiz.*—The soil of this area has everywhere a fairly high sand content. The clay and silt constituents vary from twenty to sixty per cent. Dry road surfaces through the area are hard. When the clay content is high the surfaces have considerable strength, and are not easily broken into loose material. None of the soil, however, has any particular stability when wet, and the clayey phases become sticky and adhere to wheels rather badly.

<sup>1</sup> Upham assigns a glacial origin to these deposits, similar to the eskers northeast of Winnipeg.







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<sup>1</sup> Silt and clay, 20 to 60 per cent.

Compressive strength, dry, 400 to 1,000.

Bearing strength, wet, 5 to 10.

*Assiniboine delta soils.*—The material thrown out by the Assiniboine river into its delta would seem to be a fine, silty aggregate with a low sand content. This material is seen laid down in strata all through the area especially in cuts and excavations. It is often covered by varying thicknesses of modified material, sandy in nature. Parts of the delta area are quite barren because of the accumulation of sand, devoid of fine material, heaped into dunes.

The silty soil makes good tillable land. Road surfaces composed of it are hard and durable when dry, but unstable when wet, and very sticky.

Sand, 0 to 25 per cent.

Compressive strength, dry, 1,500 to 2,000.

Bearing strength, wet, 10 to 15.

The sandy phases of the delta soil vary from quite fine material, containing a fairly high per cent of clay and silt, and which is cultivated to the loose, drifting sand among the dunes. Roads through this type of soil are loose and heavy when dry. When wet, they have more stability than the silty soils, and are not sticky.

Clay and silt, 0 to 50 per cent.

Compressive strength, dry, 0 to 500.

Bearing strength, wet, 15 to 30.

*Soil of the Portage Plains and eastward toward Stonewall.*—Clay becomes the predominating constituent in this area, and although much of the soil has quite a high percentage of sand, the sticky, plastic clay is present in sufficient quantity to impose its characteristics upon the soil. Roads through this area are for the most part hard and serviceable when dry, but unstable and very sticky when wet, adhering badly to wheels.

Sand, 25 to 50 per cent.

Compressive strength, dry, 1,000 to 1,500.

Bearing strength, wet, 5 to 15.

*Clay area of the Red River Valley.*—As the Red river is approached, the soil becomes very clayey, with less and less admixture of sand, until this constituent becomes insignificant. Roads through this area are very hard when dry, with large shrinkage cracks. When wet, the road surface swells and gets soft and very sticky. This type of road is nearly impassable when wet.

Compressive strength, dry, 1,500 to 2,000 +.

Bearing strength, wet, 15 to 20.

The Assiniboine river through the clay area has deposited in its banks a soil which is silty and apparently light in nature. This type of material appears in places on the surface of roads following the river. It has a considerable clay content, however, and while it does not get hard as when dry, is, when wet, very nearly as unstable and sticky as the clay.

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<sup>1</sup> The tests applied to soils were described in the Summary for 1918, page 173. Compressive strength figures are obtained by making compression tests on dried cylinders of the soil moulded while damp under a pressure of 132 kilos per square centimetre. The bearing strength is the weight necessary to cause a right angled V-shaped blade, two-tenths of an inch thick, to penetrate the soil to a depth of one inch when the soil is in the condition that it is on a road surface after a soaking rain. The values given for these tests have only comparative significance.



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*Light soil to the East of Winnipeg.*—The clay soil east of the Red river becomes more sandy until at about twenty-five miles it is decidedly light. Road surfaces in this area are quite stable when dry, and when wet still show considerable stability, and are not sticky.

Clay and silt, 25 to 60 per cent.

Compressive strength, dry, 400 to 600.

Bearing strength, wet, 30 to 60.

Work is being continued with a view to determining ways and means of obtaining stable aggregates, with minimum modification of the various soil types that have been noted.

CHARACTERISTICS OF THE GRAVELS OCCURRING IN THE BEACH AND ESKER DEPOSITS THROUGHOUT THE AREA.

The gravels throughout the area are everywhere very similar in composition. Approximately, 75 per cent of the pebbles consist of magnesian limestone, the balance being granite and gneiss. The deposits in the neighbourhood of Brandon contain an appreciable percentage of shaly pebbles, which split into thin layers when exposed. Practically, none of the gravels contain more than 5 per cent of very fine material passing the 100-mesh sieve. The percentage of the gravel larger in size than one-fourth of an inch, falls pretty uniformly within the limits of 25 to 35 per cent. Of this coarser material, three-fourths of it is less in size than three-fourths of an inch. The material in the esker deposits northeast of Winnipeg tends to be somewhat coarser than this, while gravel from the two small deposits north of the Assiniboine river in the municipality of St. Francois Xavier; in the Ossowa beach-line; and in the Norcross beach-line; are finer. Material in the Burnside beach and the Kinosota ridge can hardly be called gravel. It is better described as a sand with particles seldom larger in diameter than one-fourth of an inch.

## II.

### ROAD MATERIALS IN ROCKY MOUNTAINS PARK, ALTA.

About six weeks of the field season of 1919 were spent in Rocky Mountains park: extending—in a more detailed way—the start made in 1918. Materials along the auto routes in the western part of the park were examined and sampled, and the various conditions affecting the road building problem noted.

An auto road runs up the Bow valley from Banff, keeping to the right-hand side of the river. A heavy tourist auto traffic passes over this road for about 16 miles to Johnston's creek. About 3½ miles farther up the valley from Johnston's creek the road forks. One branch continues to follow the right-hand side of the Bow river for 6½ miles farther. The road grade then ends, but construction work is proceeding, which will extend it as far as Laggan and Lake Louise. The other branch crosses the Bow river, ascends the left-hand side of the Bow valley to the Vermilion pass, and proceeds into British Columbia. This road will, in the near future, be constructed through to the Columbia valley. It will then be possible to motor from the prairie country at Calgary, to Banff; to Windermere, B.C.; in the Columbia valley, to Lethbridge, and back to the plains. With the completion of this road grade, it is no exaggeration to say that one of the most magnificent scenic routes to be found anywhere in the world will have been made accessible to the motoring tourist. The charms of this wonderful belt-line trip up through the tips of the Rockies cannot fail to attract a great stream of tourist traffic, if anything like an adequate road grade and surface can be provided.



TABLE I.

Results of Tests on Gravel Samples, Rocky Mountains Park, Alta.

Location.	Character of Gravel.				Mechanical Analysis.											
	Composition of Pebbles.		Proportion of Gravel to sand.		Gravel.					Sand.						
	Per cent of.		Per cent of.		Per cent retained on screens.					Per cent retained on sieves.						
	Inter-mediate.	Soft.	Gravel.	Sand.	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Passing 200
Gravel from flat 18.8 miles west of gate..	95	5	60	40	56	8	9	11	16	20	9	11	18	19	10	13
Gravel pit at Road Forks.....	90	10	55	45	29	9	13	22	27	24	15	19	22	12	4	4
Gravel pit 0.3 mile west of Road Forks {	60	40	60	40	24	9	13	23	31	29	22	20	12	5	3	7
			55	45	22	8	12	21	37	22	21	22	14	7	4	10
Gravel pit in cut 0.7 mile west of Forks. {	95	5	60	40	53	13	8	10	16	23	10	13	26	20	4	4
			70	30	45	18	12	16	19	18	12	16	26	17	5	6
Gravel pit 1.2 miles west of Forks..... {	95	5	60	40	34	12	12	18	24	26	20	20	15	7	4	8
										27	19	19	17	8	3	7
Gravel pit 2.4 miles west of Forks... {	80	20	45	55	39	7	10	14	30	20	12	12	13	12	9	22
			45	55	38	8	10	14	30	25	13	11	11	10	8	22
Gravel pit 3.8 miles west of Forks..... {	95	5	60	40	23	9	13	28	27	22	10	13	20	17	7	11
			40	60	15	10	10	27	38	18	11	17	21	15	7	11
Gravel pit 4.3 miles west of Forks..... {	95	5	35	65	33	13	10	21	23	20	17	22	25	8	2	6
			30	70	18	11	13	21	37	15	18	29	25	6	2	5
Gravel exposed in a cut on top of boulder clay hill 6.3 miles west of Forks {	75	25	50	50	38	9	9	15	29	19	15	18	19	13	7	9
Gravel exposed in cut B.C. Road 1.2 mile from Fork.....	75	25	60	40	32	8	11	21	28	28	20	20	15	6	3	8
Gravel exposed in cut 9.7 miles from Fork, B.C. Road.....	53	37	55	45	25	24	14	16	22	22	16	24	16	3	2	17
Gravel, B.C. Road 10.9 miles from Fork	80	20	45	55	15	21	16	22	26	25	15	15	15	10	6	14
Gravel from beside river bank, B.C. Road 13.5 miles from Fork.....	80	20	50	50	50	10	12	16	12	7	7	12	32	21	7	14

<sup>1</sup>The composition of pebbles from a deposit is determined by inspection of about a hundred representative pebbles. They are classed as durable, intermediate, or soft, according as they are composed of rock which would show a per cent of wear of less than 3, between 3 and 6, or more than 6, respectively. These three classes mean, practically, pebbles composed of fresh rock of igneous origin, fresh limestone, and weathered pebbles of both types.



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TABLE II.

Results of Tests on Boulder Clay Samples, Rocky Mountains Park, Alta.

Location.	Character of Gravel.				Mechanical Analysis.											
	Composition of Pebbles.		Proportion of Gravel to sand.		Gravel.					Sand.						
	Per cent of.		Per cent of.		Per cent retained on screens.					Per cent retained on sieves.						
	Inter-mediate.	Soft.	Gravel.	Sand.	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Passing 200
0.5 mile west of railway crossing gate.	90	10	45	55	10	15	16	28	31	24	9	6	8	17	9	27
0.9 mile west of gate.	95	5	20	80	11	16	18	22	33	6	5	5	8	10	11	55
1.5 mile west of gate.	90	10	55	45	30	17	13	15	25	14	12	13	13	16	13	19
1.7 mile west of gate.				100						1	1	1	1	1	10	85
2.5 mile west of gate.	80	20	70	30	28	18	14	16	24	22	12	8	7	8	10	33
			65	35	52	11	10	14	13	27	7	6	7	10	12	31
17.0 miles west of gate										9	6	6	9	14	13	43
1.4 mile W. of Forks.	75	25	20	80		27	17	29	27	8	5	6	8	11	11	51
			15	85		40	8	21	31	9	6	6	8	10	9	52
4.9 miles W. of Forks.	60	40	30	70	32	17	12	18	21	14	10	11	13	13	10	29
5.8 miles W. of Forks.	65	35	35	65	44	6	8	17	25	7	5	6	10	9	9	54
6.7 miles W. of Forks.	65	35	20	80	31	23	11	15	20	4	3	4	5	7	6	71
B. C. Road 3.8 miles from Forks.	75	25	35	65	23	19	12	20	26	14	8	9	11	13	14	31
B. C. Road 5.8 miles from Forks.	65	35	35	65	40	23	6	14	17	15	10	12	17	16	10	20
B. C. Road 7.0 miles from Forks.	80	20	45	55	15	13	17	23	32	39	18	12	8	5	4	14
B. C. Road 8.1 miles from Forks.																
B. C. Road 8.1 miles from Forks.	75	25	40	60	24	12	16	20	28	22	15	12	11	10	8	22
B. C. Road 12.7 miles from Forks.	70	30	55	45	34	15	8	20	23	39	18	9	5	3	3	23
B. C. Road 13.9 miles from Forks.	85	15	55	45	52	13	9	11	15	24	12	8	5	5	7	39
B. C. Road 14.9 miles from Forks.	70	30	65	35	12	32	24	19	13	22	13	14	15	9	5	22

<sup>1</sup> See footnote on previous page.



TABLE III.

Results of Tests on Samples of Gravel, Rocky Mountains Park, Alta.

Location.	Character of Gravel.				Mechanical Analysis.											
	Composi- tion of Pebbles. Per cent of.		Proportion of Gravel to sand, Per cent of.		Gravel. Per cent retained on screens.					Sand. Per cent retained on sieves.						
	Inter- medi- ate.	Soft.	Gra- vel.	Sand.	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	as- sing 200
Gravel pit 1·3 mile west of railway cross- ing gate.....	85	15	45	55	25	10	10	20	35	31	12	11	12	13	8	13
			50	50	9	9	13	30	39	31	17	13	9	7	5	18
			65	35	20	12	13	25	30	42	14	9	7	7	6	15
Rough rock fragment deposit, 6 miles west of gate.....	90	10	60	40	19	6	22	14	39	47	8	3	2	4	10	26
			60	40	17	13	16	21	33	38	10	6	4	5	10	27
Deposit of angular ma- terial cemented hard with silt. 6·9 miles west of gate.....	70	30	60	40	39	8	11	16	26	24	13	12	11	11	8	21
			50	50	21	8	10	25	36	23	13	11	12	10	9	22
			55	45	22	8	12	26	32	19	12	10	10	12	10	27
Gravel exposed in ditch. Same de- posit as 7·4 miles W. of gate.....	65	35	60	40	21	11	12	22	34	4	13	6	4	6	10	17
Gravel in small pit 7·5 miles W. of gate....	80 95 95	20 5 5	65	35	29	8	12	20	31	37	13	9	6	7	9	19
			75	25	42	10	12	17	19	36	10	6	5	8	13	22
			55	45	23	7	15	24	31	33	9	5	5	9	14	25
Pit in deposit of an- gular material ce- mented hard by silt, 8·8 miles west of gate.....	95	5	60	40	36	9	11	19	25	28	10	6	6	7	8	35
Pit of gravel with streaks of sand. 9·3 miles west of gate...	95 95 95	5 5 5	70	30	36	9	13	19	23	36	12	8	6	7	9	22
			70	30	37	10	12	18	23	0	1	3	8	11	16	61
			70	30	38	7	9	22	24	30	11	9	11	14	10	15
Gravel from below silty top soil, 9·4 miles west of gate	75	25	65	35	31	13	17	19	20	31	8	6	8	12	11	24
Gravel pit, 10 miles west of gate.....	75 90 90	25 10 10	70	30	51	10	10	14	15	26	12	10	8	10	12	22
			65	35	38	13	13	18	18	28	13	10	7	8	9	25
			75	25	38	10	12	19	21	30	11	8	9	13	12	17
Gravel pit. Angular pebbles. 10·9 miles west of gate.....	95 65 65	5 35 35	65	35	38	11	13	19	19	35	13	8	7	10	10	17
			55	45	28	10	12	22	28	27	12	8	8	12	13	20
			60	40	25	10	15	25	25	28	12	11	12	12	9	16
Test pit of gravel in flat 12·0 miles from gate....	95	5	70	30	27	12	12	24	25	37	8	6	9	11	11	18
Test pit in flat 12·4 miles W. of gate..	90	10	65	35	25	11	16	23	25	33	14	11	10	12	9	11
Test pit in flat 12·5 miles W. of gate...	85	15	35	65	4	4	11	32	49	35	12	8	8	16	10	11
Gravel underlying flat 14·8 miles W. of gate	70	30	60	40	48	8	10	15	19	20	14	15	15	12	11	13
Gravel underlying flat 15·0 miles W. of gate	65	35	55	45	29	12	12	21	26	28	17	18	18	8	4	7
Gravel underlying flat 15·2 miles W. of gate	70	30	55	45	25	10	14	23	28	33	17	10	11	11	6	12



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TABLE III.—*Concluded.*Results of Tests on Samples of Gravel, Rocky Mountains Park, Alta.—*Concluded.*

Location.	Character of Gravel.				Mechanical Analysis.											
	Composi- tion of Pebbles. Per cent of.		Proportion of Gravel to sand. Per cent of.		Gravel. Per cent retained on screens.					Sand. Per cent retained on sieves.						
	Inter- medi- ate.	Soft.	Gra- vel.	Sand.	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Pas- sing 200
Gravel from pit at Johnson creek. 15.5 miles W. of gate....			35	65		6	15	29	50	3	5	12	30	29	9	12
	70	30	55	45	25	10	14	23	28	13	12	25	27	14	4	5
	95	5	60	40	31	9	13	22	25	19	11	16	25	19	5	5
Gravel pit, 16.7 miles west of gate...	95	5	65	35	34	11	13	20	22	31	9	6	13	20	6	15
			55	45	21	8	13	24	34	22	32	20	12	5	2	7
Gravel exposed in cut 17.2 miles west of gate. ....	95	5	50	50	6	5	9	25	55	35	9	12	26	11	2	5
	95	5	75	25	35	9	12	22	22	30	13	11	16	8	4	18
			60	40	26	10	13	26	25	27	15	15	17	12	5	9
Gravel pit 18.2 miles west of gate.....			70	30	35	10	13	19	23	34	15	10	15	9	4	13
	95	5	85	15	41	18	15	19	7	13	4	3	6	18	25	31
			90	10	60	15	10	10	5	37	10	6	9	12	9	17



TABLE IV.

Results of Tests on Gravel Samples taken from Gravel Road Surfaces.  
Rocky Mountains Park, Alta., and Manitoba.

Location.	Character of Gravel.				Mechanical Analysis.											
	Composi- tion of Pebbles. Per cent of.		Proportion of Gravel to sand. Per cent of.		Gravel. Per cent retained on screens.					Sand. Per cent retained on sieves.						
	Inter- medi- ate.	Soft.	Gra- vel.	Sand.	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200	Pas- sing 200
0.5 mile W. of gate...	80	20	40	60	4	21	13	23	39	19	12	9	9	10	10	31
9.4 miles west of rail- way crossing gate...	80	20	65	35	30	19	12	16	23	15	13	11	9	10	11	31
12.5 miles west of gate	85	15	55	45	14	19	12	22	33	14	8	7	10	13	15	33
0.2 mile west of Forks.....	70	30	30	70	3	20	16	23	38	24	14	13	10	7	5	27
2.5 miles west of Forks.....			60	40	29	13	10	19	29	22	12	12	12	11	8	23
2.8 miles west of Forks.....	65	35	65	35		10	10	29	51	37	17	12	10	11	5	8
4.4 miles west of Forks.....			35	65	26	7	13	23	31	18	18	22	22	8	3	9
From East Kildonan Rd., Winnipeg, Man. Gravel over gumbo soil.....	85	15	35	65		20	16	30	34	15	14	14	13	11	5	28
From road toward Birds Hill, Man Gravel over gumbo soil.....			30	70		13	17	23	47	14	12	14	15	11	7	27
From gravel road over clay soil near Win- nipeg, Man.....			25	75	11	23	15	19	32	12	9	17	22	12	4	24
From gravel road over clay soil near Win- nipeg, Man.....			25	75	27	12	8	18	35	12	11	16	22	12	5	22
From sand-clay road in clay country near St. Francois Xavier, Man.....			5	95	0	15	6	23	56	7	11	20	18	11	6	27
From gravel road in till soil south of Brandon, Man.....			35	65	8	28	12	21	31	11	10	17	17	13	9	23
From gravel road over sandy silty soil be- tween Neepawa and Arden, Man.....			25	75	12	7	10	27	44	23	8	6	10	15	9	29







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Gravel occurrences and boulder clay deposits were noted and sampled along the roads just mentioned, as far as one could reach by the use of a motor car. Samples were also taken, at a number of places, from surfaces of stretches of gravel road that were giving good service. The results of tests are recorded in the accompanying tables. The location of points of sampling are indicated by the distance in miles from the railway crossing west of Banff station, or from the road forks about 19 miles up the Bow valley. The distances were determined by means of the speedometer of the car used in the work: their reliability can be judged accordingly.

Materials for the building or surfacing of roads in mountainous country such as that of Banff, must, for the most part, be immediately accessible from the right of way. The road grade is generally established on sloping country, and is often literally excavated out of the mountain side. It is not then a question of going afield until a suitable type of material is found. Instead, the problem is to accomplish the result desired by the use of the material encountered in constructing the road, where it must be constructed to secure the proper grade. The roads naturally follow, as much as possible, the courses of the valleys. The valleys are filled with drift material, which is generally stony, and varies from gravel to stony, bouldery soils, or boulder clay. A mountain road nearly always cuts through shoulders of gravelly material at frequent intervals. But unfortunately, the material is seldom just what it ought to be, to provide a source of really suitable surfacing gravel. It will be too coarse or unevenly graded, deficient in fine material, or full of silt and clay.

The Rocky Mountains Park roads—as can be judged from the table of results of tests—run through plenteous material of a gravelly nature. Much of it has been used for road surfacing and with very fair results. The most difficult condition met on these roads is long stretches of road grade passing through boulder clay. This material contains a high proportion of stone, but it is not evenly graded as to size, and has an excessive percentage of silt and clay. This fine material makes the boulder clays hard when dry, but renders a road surface sticky, slippery, and unsafe, when wet, and puts it in a condition to be greatly damaged by traffic. Much of the road from the forks up through the Vermilion pass is situated in boulder clay, with practically no occurrences of good gravel.

While the boulder clays are too rough and clayey, and many of the gravel deposits are faulty in one way or another, it would seem that none of these materials are really far removed from being good aggregates. For the purpose of comparison and interpretation, the results contained in the tables of tests have been condensed in the preceding table, and expressed by limiting values. These limits are chosen to include in each case the large majority of the individual values. There are results for 60 samples of gravel. These have been bunched into three groups of twenty each, taking them in the order in which they are found in the table. There are about twenty results for samples of boulder clay. Then there are seven samples taken from gravel road surfaces in Rocky Mountains Park, and seven similar samples from Manitoba.

The limits for analysis of samples from gravel road surfaces can be taken as reference limits. The surfaces sampled were all well compacted, stable, and apparently giving good service. Two loose, uncompacted gravel surfaces were also sampled. Comparing the values for the gravels with each other, and with those for the samples from road surfaces, no very obvious differences are apparent. The most important difference is probably in connexion with the proportion present of material passing 200 mesh. This is the material that binds and makes the difference between a compacted and a loose surface. The gravels tend to have less binding material than is found in a compacted road surface. The two samples taken from surfaces which have failed to bind are low in material passing 200 mesh. All the compacted road surfaces examined contain from 25 to 35 per cent of material passing 200 mesh. It would appear that if such proportion of this constituent is not present in the original



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gravel used in construction, the road bed will remain loose until the fine material is brought up to a sufficiently high value, either by abrasion of the pebbles or by introduction of clay and silt from the soil in the neighbourhood. Some of the gravels have a heavy percentage of large sized pebbles which make them rough for surfacing.

The boulder clays show wider limits of variation. The proportion of pebbles larger than one-fourth of an inch, to that of sand and clay, shows a wide range of variation. But the boulder clays obviously differ the most from serviceable surface aggregates in the high silt and clay content. Otherwise, they show great similarity to the gravels and the road surface aggregates.

Boulder clay is about the only material easily available for many stretches of road. It seems to be regarded as a rather hopeless case. But yet slight modification in composition would make much of the boulder clay coincide well with aggregates that are giving good service. Boulders of all sizes, and in quantities, occur in the boulder clay. If these boulders, in controlled amounts, were run through a crusher, together with the boulder clay itself, a product could be obtained in which the pebble and sand content would be increased, and consequently, the clay and silt percentage reduced to the proper extent.

There is great need of better methods of performing and recording mechanical analyses and of relating the results to the characteristics of the corresponding aggregates as displayed as a road material. Only in this way will it be possible to adequately examine gravel material, and thus determine just what modification, if any, is advisable to secure a serviceable aggregate. The Road Materials Division is working on this problem.

## III.

ROAD MATERIAL INVESTIGATIONS IN CHATEAUGUAY AND BEAUFARNOIS COUNTIES, QUE., FROM MORRISBURG, ONT., ALONG THE ST. LAWRENCE RIVER TO THE QUEBEC BOUNDARY, AND IN THE NEIGHBOURHOOD OF RENFREW, ONT.

HENRI GAUTHIER.

A considerable proportion of the time of the writer, during the field season of 1919, was spent in road materials investigations, which, besides supplying information of use in highway construction planning, was also calculated to fit into the material surveys and studies being conducted by the Mines Branch under the direction of Mr. Keele in connexion with the St. Lawrence river power development. A complete road material survey of parts of the counties of Chateauguay and Beauharnois was made. The more important deposits of gravel occurring within reach of the St. Lawrence river from Morrisburg to the Quebec boundary were re-sampled for more complete laboratory study.

Dr. Morley E. Wilson, of the Geological Survey, Canada, has been engaged in geological mapping and studies of the country in the neighbourhood of Renfrew, Ont. Acting on his suggestion, and making use of the information he has secured, a programme of sampling for laboratory study of the various types of rock deposits and of gravel in this vicinity was undertaken. It was thus possible to quickly secure a considerable amount of useful information in a part of the country where important highway construction is being considered, and to supply to Dr. Wilson additional practical data for the report he is preparing.



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Sampling of deposits of material encountered in the survey from Prescott to Kingston—conducted by the Division—was also a part of the field duties of the season.

Results of tests on samples collected and studied in the laboratory are presented in the following tables:—

TABLE I.  
RESULTS OF TESTS ON BED-ROCK  
Chateauguay and Beauharnois Counties, Que.

Locality.	Rock Type.	Physical Properties.					
		Wear.	French coef of wear.	Toughness.	Hardness.	Specific gravity	Absorption in lb. per cu. ft.
Lapi�ne quarry, Bellerive.....	Beekmantown dolomite	1.86	21.6	24	18.1	2.74	1.04
Magloire Theoret quarry, Bellerive.....	“ “	2.50	16.0	21	16.1	2.79	0.40
Alexis Dorais quarry, St. Timoth�e....	“ “	3.06	13.1	14	16.1	2.85	0.57
Arsene Meloche quarry, St. Louis de Gonzague.....	“ “	2.58	15.5	25	17.8	2.76	0.62
Montpetit quarry, Beauharnois.....	Potsdam sandstone.....	2.34	17.1	6	17.3	2.65	0.74
Alphonse Faubert's farm, Bellerive Station, Ville de Lery.....	Beekmantown dolomite.	2.30	17.4	23	18.0	2.74	0.32
Laberge quarry, Chateauguay.....	“ “	2.38	16.8	15	18.2	2.77	0.38

Renfrew District, Ont.

Jamieson quarry, Renfrew.....	Crystalline limestone.....	4.42	9.1	4	11.6	2.77	0.19
At water tower, immediately south of Renfrew.....	Basic granite-gneiss.....	2.3	17.4	17	17.4	2.80	0.29
Two miles southwest of Renfrew..	Acidic granite-gneiss	1.94	20.6	16	18.5	2.70	0.44
Pinnacle quarry, 1½ miles northwest of Renfrew..	Hornblende-schist . .	1.93	20.7	17	17.0	3.04	0.41
7 miles northwest of Renfrew	Diabase	2.2	18.1	21	18.4	3.03	0.37
Municipal quarry, 1½ miles northeast of Renfrew.....	Crystalline limestone....	5.16	7.8	4	13.4	2.79	0.26
5 miles north of Renfrew ...	Gabbro..	3.39	11.8	11	18.3	3.10	0.66



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TABLE II.

## Character of Deposits of Field Stone.

Location.	Average of whole Deposit					Remarks.
	Dolomite.	Igneous	Sandstone.	Stone over 1 ft. diameter.	Total yardage.	
	%	%	%	%		
De Salaberry island along north shore road	45	15	40	35	800	Dolomite is weathered on the surface but fairly fresh inside. Sandstone is soft and a poor road material.
Northeast end of De Salaberry island.....	50	10	40	50	1,000	Igneous is largely composed of gneisses.
Stock piles along road north of Bellefave	60	10	30	0	100	About 50 per cent of the sandstone is very soft. The dolomite is fairly fresh.
	45	5	50	0	125	
Parish of St. Timothée south of village	65	5	30	33	1,500	Dolomite is fine grained, bluish grey, somewhat weathered to brownish colour on the surface. It has been used with success in macadamizing work. Both the soft friable and the tough quartzitic varieties of the sandstone occur in about equal amount. The latter can be used with advantage in foundation work.
Parish of St. Timothée, Con. I and II, west of station road	70	5	25	33	1800	
Parish of St. Timothée, Con. II, east of station road.....	65	5	30	30	2,500	
Parish of St. Timothée, Con. II and I.....	20	0	80	50	2,000	
Parish of Ste. Madeline, Con. II and III, from N.Y. Central R. line to G.T.R. line	55	5	40	20	5,000	Dolomite partly fresh, partly weathered. Sandstone is soft.
Con. IV—4 miles south of Valleyfield	60	0	40	10	900	
Parish of St. Louis de Gonzague, west of village, Con. VI and VII.....	60	5	35	15	8,000	
South of village of St. Stanislas de Kostka	75	5	20	20	1,500	
Con. IV and V, 3 miles southeast of St. Stanislas.....	85	5	10	20	2,500	
1½ miles west of village of Beauharnois	5	5	90	25	1,500	
Along lake shore from 2 miles east of Beauharnois to Woodlands in Chateauguay county	80 to 100	0 to 5	0 to 20	20		The amount of field boulders estimated, on account of the built-up character of the area where they occur, not less than 20 cubic yards.



TABLE III.  
RESULTS OF TESTS OF GRAVEL SAMPLES.  
Along St. Lawrence River, from Morrisburg, Ont., to Quebec Boundary.

Sample No.	Owner and Location of Deposit.	Character of Gravel.		Mechanical Analysis.															Remarks.		
		Composition of pebbles (%).		Gravel.						Sand.											
		Dur-able.	Inter-me-diate.	Proportion of gravel to sand.		Percent retained on screens.						Percent retained on sieves.									
				Gra-vel.	Sand.	2½"	2"	1½"	1"	¾"	½"	¼"	8	14	28	48	100	200		Pass-ing 200	
1	A. Cougler, Lot 35, Con. III.					5	18	19	20	8	14	16	28	20	22	17	7	2	4	Rather fresh limestone pebbles.	
2	Williamsburg tp.					10	14	19	15	10	13	19	28	20	21	17	8	2	4	Samples were taken 10 feet apart and at different level.	
3	Two miles south of Grantley.		5	50	50	8	12	10	20	13	16	21	17	15	27	30	9	1	1	Flaggy pebbles dense to fine grained est.	
4	Lot 5, Con. VI.		10	76	24	30	10	7	16	8	13	16	37	20	17	15	6	2	3		
5	Williamsburg tp.		5	69	31	4	10	18	20	12	15	21	47	27	17	6	1	1	1		
6	W. N. Hollister pit, Lot 27, Con. IV, Osnabruk tp.			71	29	20	26	9	16	8	10	11	22	20	20	12	21	3	2	Represents finest material in pit. Most is bouldery gravel. Fresh est.	
7	McGowan pit, Lot 13, Con. III, Osnabruk tp		50	91	9	10	8	16	32	14	12	8	31	11	10	16	10	10	12	100 per cent Black River est. shaly.	
8	N.Y. Central R. pit, Northfield Station, Con. VIII, Cornwall tp.	10	40	74	26	31	9	15	20	8	9	8	21	14	22	27	7	2	4	About 50 per cent of the pebbles are est. but 50 per cent of it is weathered and soft.	
9			85	63	37			14	24	20	27	15	17	16	15	33	12	4	3		
10			95	46	54			18	25	12	16	29	14	15	14	36	17	1	3		
11	McLeuds pit, Lot 24, Con. VIII, Cornwall tp		80	62	38				7	9	21	63	37	21	8	8	7	7	12	Black River est., soft includes weathered pebbles.	

Renfrew District.

12				83	17	36	18	12	20	21	25	22	25	15	15	11	14	11	8	16
13				73	27			7	17	6	7	9	15	15	21	31	31	9	3	6
14	U. J. McQuillon pit, Lots 30, 31, Con. VI, Cornwall tp.			72	28	39	18	11	15	5	5	7	17	15	19	30	8	3	8	8
15				29	71			27	18	13	11	31	13	13	18	25	15	8	8	8
16	Winfall pit, Lots 33 to 36, Con. V, Cornwall tp.			54	46			17	18	14	18	22	18	9	8	29	31	3	3	2
17				65	35			21	17	13	13	16	23	12	10	29	22	2	2	2
18				77	23	26	20	7	8	12	13	14	35	12	10	22	17	2	2	2
19				67	33	14	8	13	20	11	14	20	31	15	12	25	15	1	1	1
20	Thos. Cleary pit, Moulinette, Lot 29, Con. IV, Cornwall tp.			55	45	10	10	8	21	10	18	23	19	12	26	26	9	4	4	4
21				66	34			20	25	15	18	22	15	13	17	30	15	4	6	6

Dark coloured dense Black River lime-stone.

Fresh est pebbles.



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22	Fallon Bros. pit, Cornwall, Lots 7 and 8, Con 11, Cornwall tp.	50	50	65	35	24	3	12	20	10	11	20	30	27	17	11	8	3	4	Soft includes weathered est. Intermediate are est. with a small per cent of gneisses, schists, and sandstone.
23		50	50	65	35	50	3	12	9	5	9	12	25	20	20	20	7	3	5	
24		50	50	54	46	16	13	19	22	8	8	14	15	17	20	24	13	5	7	
25		40	60	46	54		24	6	16	10	16	28	20	20	20	20	9	4	7	
26	John McIntosh pit, St. Andrews West, Lot 12, Con. V, Cornwall tp....	75	25	60	40	10	21	19	12	10	10	18	18	20	23	23	10	2	4	
27		75	25	57	43	23	6	18	14	10	11	16	27	16	18	20	11	3	5	
28	Williamstown pit, 2 miles west of town. Charlottenburg tp.	95	5	30	70		6	11	60	7	16	60	39	30	15	6	3	2	5	Pebbles are composed entirely of Black River limestone, and are of angular shape.
29		95	5	60	40		28	3	16	13	18	21	20	13	15	30	12	4	6	
30		95	5	57	43		13	5	16	12	19	35	32	14	9	21	11	5	5	
31		95	5	62	38		10	9	21	11	22	27	35	28	20	8	3	2	4	
32	Riviere Bandet, Que., pit south of river road	95	5	68	32		20	14	18	9	13	26	47	17	7	9	7	5	8	Intermediate are shaly limestone with small per cent of sandstone.
33		95	5	82	18		10	10	37	24	20	9	20	17	18	15	9	7	11	
34	Municipal pit, town of Renfrew	90	10		100								6	13	5	30	47	14	4	
35		90	10		100				6	10	22	62	24	35	28	10	3	1	2	
36		85	10	27	73			22	26	15	13	24	28	20	18	11	6	9	8	Rounded pebbles. Much coarser gravel to be found in north- western wall of pit with large per cent of boulders.
37		60	25	16	84															
38	G.T.R. pit, 2 miles southeast of Renfrew			18	82				13	9	22	56	14	13	20	37	12	2	1	Rounded grains.
39		95	30	50	50		19	10	18	11	13	27	27	22	15	14	12	6	4	Rounded pebbles.
40		40	30	47	53			10	13	10	17	50	40	19	10	8	13	7	3	Rounded pebbles.
41	1 1/2 mile northwest of Renfrew				100									3	16	38	30	10	9	Brown sand.
42					100									1	12	42	30	11	4	Reddish sand.
43		30	30	55	45	11	10	18	19	10	9	23	24	24	22	15	7	4	4	Rounded pebbles.
44		50	20	22	78		8	7	8	7	8	77	29	30	21	11	5	2	2	Rounded pebbles.
45		30	20	50	50	15	14	17	18	6	10	20	26	32	22	11	5	2	2	Rounded pebbles.

(1) Durable stands for igneous rocks of fresh character.  
Intermediate stands for fresh limestone, dolomite and sandstone.  
Soft stands for any of the above rocks if weathered, schists, shales.



TABLE IV.  
Results of Tests on Gravel Samples.

Sample No.	Fine-ness modulus	Per cent clay and silt	Colour test.	Sand Mortar 1: 3 mix (1)					Remarks.
				Water used.	Inside strength lbs. per sq. in.		Compressive strength lbs. per sq. in.		
					7 days.	28 days.	7 days.	28 days.	
(Along St. Lawrence River from Morrisburg, Ont., to Quebec Boundary.)									
1	3.27	8.0	100	12	226	366	2,720	4,000	Dark coloured sand containing shells in large quantity.
2	3.25		50	13	258	411	2,740	3,900	
3	2.95	1.3	50	11	411	520	3,850	5,540	Dark coloured sand, CuCO <sub>3</sub> on pebbles, moderate amount of shells, rather clean.
5	4.07	1.3	0	10	339	440	2,850	3,580	
9	2.72	7.0	100	11	261	396	2,310	3,620	No shells, dark coloured sand.
12	2.57	20.0	600	20	100	157	920	1,345	Very dusty sand, clayey, carrying impurities
13	2.69	7.6	100	14	230	329	2,370	3,700	Yellowish-brown sand with shells, rather clean.
15	2.36	12.0	0	12	336	441	2,800	4,400	Clean sand, no shells.
16	2.39	4.1	50	11	241	300	1,760	2,250	Clean sand with a good deal of shells up to 1/4 inch in size.
19	3.16		0	11	319	405	2,800	3,600	
23	3.12	8.1	400	12	277	371	2,220	3,780	Very little shells, some impurities.
25	2.89	14.0	400	15	218	313	2,380	3,220	
27	3.04	11.1	75	12	260	378	2,490	3,700	Dusty, but no injurious impurities.
(Renfrew District.)									
34	1.23		25	17	129	198	950	1,560	Clean reddish sand carrying mica in moderate amount.
35	2.45	4.0	0	12	207	347	1,635	2,260	Grains cemented together with CaCO <sub>3</sub> iron oxide present, no organic matter.
37	3.02	15.3	0	10	440	583	3,680	5,350	Clean sand carrying some clay.
41	1.48	16.2	600	15	126	227	1,360	2,160	Yellowish-brown sand, mica, and iron oxide present.
42	1.54	7.6	0	16	160	261	1,166	2,220	
43	3.19		0	13	272	360	2,250	2,970	Reddish sand, mica in moderate quantity.
45	3.51		0	10	445	505	3,000	4,435	Clean reddish sand.

(1) Ottawa standard sand, strength of 1:3 mortar: tensile, 7 days— 174 lbs. per sq. in.  
" 28 days— 292 lbs. per sq. in.  
Compressive 7 days—1,540  
" 28 days—2,275

IV.  
ROAD MATERIALS AVAILABLE ALONG THE ST. LAWRENCE RIVER,  
BETWEEN PRESCOTT AND KINGSTON.

R. H. PICHER.

An investigation of road materials for highway construction between Prescott and Kingston, along the St. Lawrence river, was conducted during the field season of 1919. The work was started one mile east of the Algonquin-Maitland road in Augusta township, i.e., at the western limit of the area examined in 1915, and was carried on as far west as the Joyceville side road in Pittsburgh township. The district covered extends along the river for a distance of 45 miles, to a depth of from 3 to 5 miles, making a total area of about 180 square miles. The Prescott-Kingston highway will probably be part of the proposed improved Montreal-Toronto trunk road.

The area examined is characterized topographically by steep-sloped, rocky ridges, separated by flat-bottomed depressions, some of which are marshy. In the vicinity of Brockville, and around Lansdowne, the country is more in the nature of a plain, with low, flat-topped hills, partly rocky, partly boulder clay, and sand.



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Rocks of the Pre-Cambrian era cover wide areas between Brockville and Kingston. The granites, quartzites, and gneisses are the most important types. Diorite, trap rock, and crystalline limestone, occur, but only in very small outcrops. Of the Palæozoic rocks, Potsdam and Beekmantown sandstones are exposed in many places among the Pre-Cambrian rocks; and north and east of Brockville there are many exposures of Beekmantown dolomites. Chazy shales and Black River limestone are seen in two small outcrops near Pittserry. The latter is exposed at many points in and around Kingston.

The unconsolidated deposits consist of boulder clay, gravel, clay, and sand. Boulder clay occurs only east of Brockville in small flat-topped hills. Gravel occurrences are all of small extent, and are found in most cases as pockets or layers in much larger sand deposits. Clay covers the largest part of the district, occupying all the flat land and the depressions between rock ridges. The largest sand deposits lie around Brockville. One of these is found three miles west of that town, where it starts as a flat table, and runs as a very narrow belt along the river shore as far as Rockport. Other deposits of very small extent occur around Gananoque.

The results of tests performed on samples collected are given in the following tables:—

TABLE I.  
Results of Tests Upon Bed-rock.

Locality.	Rock type.	Physical properties.					
		Wear	French coeff. of wear.	Tough- ness.	Hard- ness.	Speci- fic gravity.	Water absor- bed, lbs. per cu. ft.
Todd's quarry, 3 miles N.W. of Gananoque...	Syenite.	2.4	16.8	12	18.8	2.74	0.32
Keyes' quarry, close to Gananoque.	"	2.9	13.8	8	18.5	2.73	0.35
Street and O'Brien's quarry, 3 miles N.W. of Gananoque.	"	2.6	15.3	8	18.9	2.72	0.30
Dano's quarry, close to Gananoque.	"	2.5	16.3	9	18.8	2.75	0.30
Seal's quarry, 3 miles N.W. of Gananoque..	"	2.7	14.8	8	18.5	2.71	0.40
Kidd's quarry, 1½ mile N. of Gananoque..	"	2.7	14.8	8	19.1	2.69	0.27
Gordon's quarry, close to Findley station	"	2.5	16.3	8	19.1	2.69	0.24
Can. Granite Co's quarry, 1 mile E. of Bar- rieheld	Granite	2.6	15.5	9	19.2	2.69	0.32
1½ mile W. of Brockville <sup>1</sup>	"	4.1	9.9	5	18.5	2.70	0.73
5 miles N.E. of Gananoque.	Altered granite	2.9	13.8	20	19.2	2.64	0.41
1½ mile S.W. of Lansdowne .....	"	1.8	22.2	18	18.9	2.68	0.40
McKee Bros.' quarry, 1 mile N.E. of Mitchell- ville	Granite	2.3	17.4	12	18.9	2.66	0.32
2 miles W. of Mallorytown ..	"	2.1	19.1	18	19.0	2.64	0.76
3 miles N.E. of Gananoque.	Granite-gneiss.....	1.9	20.6	14	18.9	2.64	0.45
Close to Escott ..	Gneiss	2.6	15.4	14	18.2	2.72	0.27
2 miles E. of Findley station....	"	2.1	19.5	9	18.1	2.92	0.54
1 mile W. of Gananoque....	"	3.8	10.5	8	17.1	3.00	0.73
2 miles N.E. of Escott....	Diorite	2.2	18.2	16	15.6	2.82	0.33
½ mile W. of Gananoque	Gabbro ..	2.4	16.9	18	18.5	3.04	0.58
Corporation of Brockville quarry	Quartzite ..	2.7	14.8	7	19.5	2.65	0.24
Kilbourn's quarry, 2½ miles W. of Brockville.	"	3.0	13.3	8	19.5	2.65	0.41
Close to Gananoque	"	4.0	10.0	2	19.5	2.61	1.03
Bolin's quarry, 1 mile E. of Lyn	Sandstone ..	7.6	5.3	4	17.3	2.50	2.20
McDonald's quarry, ½ mile E. of Gananoque..	"	6.0	6.7	8	17.8	2.53	2.30
Worden's quarry, 2 miles N.W. of Brockville.	Dolomite ..	2.8	14.3	13	15.7	2.79	0.71
Sherwood's quarry, 1½ mile N.E. of Brock- ville	"	2.8	14.5	15	15.4	2.81	0.53
Dunham's quarry, 3 miles N.E. of Brockville.	"	3.0	13.6	11	15.4	2.81	0.75
Everett's quarry, 1½ mile N.W. of Brockville.	"	3.2	12.5	9	15.8	2.83	1.17
Everett's quarry, 1½ mile N.W. of Brockville.	Calcareous sandstone..	4.3	9.3	...	...	2.79	1.02
George's quarry, 1 mile N.E. of Brockville..	"	3.1	12.9	7	18.4	2.71	0.63
McFadden's quarry, near Pittserry.....	Limestone	3.8	10.5	9	16.7	2.73	0.17
Ruddy and Monk's quarry, Montreal St., Kingston.	"	4.4	9.0	15	14.1	2.75	0.53
Green's quarry, 1½ mile W. of Kingston	"	3.7	10.9	7	14.7	2.73	0.25
Ruddy and Monk's quarry, Perth road, Kings- ton....	"	3.8	10.5	11	16.1	2.73	0.25
McMichael's quarry, 2½ miles N.W. of Kings- ton ..	"	3.7	10.8	11	15.3	2.73	0.17
Penitentiary quarry, Kingston.	"	3.8	10.5	9	15.3	2.73	0.82
Mouldley's quarry, 1½ mile W. of Kingston	"	3.9	10.3	3	16.0	2.73	0.35
Mrs. Graham's quarry, ½ mile E. of Kingston Mills ..	"	3.4	11.8	9	16.1	2.73	0.20

<sup>1</sup>Partly weathered.



TABLE II.  
Results of Tests on Gravel Samples.

Owner and Location.	Character of Gravel.		Mechanical Analysis.										Remarks.						
	Composition %		Size %.		Gravel percentage retained on screens.						Sand percentage retained on sieves.								
	Dur-ables.	Inter-med-iate.	Soft.	Grav-vel.	Sand.	2 1/2"	2"	1 1/2"	1"	3/4"	3/8"	1/4"		8	14	28	48	100	200
Mrs. Haley's pit, N. of Maitland.	35	45	20	44	56			8	20	14	19	39	16	14	15	26	21	4	Sample from N. E. wall
Sand pit, E. of Lyn.					100					/					1	43	46	7	
Sand pit, E. of Lyn.					100											48	41	6	
Donovan Bros.' pit, E. of Escott.	42	6	52	14	86					7	6	87	39	27	7	8	11	5	3
Donovan Bros.' pit, E. of Escott.				55	45	4	4	4	13	10	23	46	43	30	16	6	2	2	1
Donovan Bros.' pit, E. of Escott.				5	95					16	15	68	3	5	13	37	29	9	4
L. Donovan's pit, S. of Escott.	25	45	30	64	36	2		5	21	19	25	28	21	17	25	24	8	3	Coarse gravel
L. Donovan's pit, S. of Escott				37	63			8	17	11	20	44	19	19	23	22	7	4	Fine, dirty gravel
J. Nadeau's sand pit, N. of Gannaque.				5	95							100	8	10	23	50	7	1	E. wall, 5 ft. from surface
J. Nadeau's sand pit, N. of Gannaque.					100									2	10	58	25	4	W. wall, 10 ft. from surface
J. Nadeau's gravel pit, N. of Gannaque.	60		40	35	65			11	18	15	21	35	23	20	19	23	9	3	Streak of gravel below sand.
J. Nadeau's gravel pit, N. of Gannaque.					100										2	5	26	39	Silt.
R. Jackson's pit, W. of Gannaque.	70	10	20	36	64	11	11	26	28	6	10	19	9	11	20	32	21	5	Streak of gravel, 9 ft. from surface.
R. Jackson's pit, W. of Gannaque.				10	90					45	19	36	3	5	14	43	25	7	3 N. E. wall, largely sand
W. McEadden's pit, Pitts-ferry	90		10	60	40	26	5	20	18	10	9	12	15	18	27	28	7	1	
W. McEadden's pit, Pitts-ferry				52	48			8	10	12	30	40	24	6	14	38	13	3	2 E. wall, gravel below sand
W. McEadden's pit, Pitts-ferry					100								3	12	39	35	8	2	E. wall, upper part.

The composition of pebbles from a deposit is determined by inspection of about one hundred pebbles. They are classed as durable, intermediate or soft according as they are composed of rock which would show a per cent of wear of less than 3, between 3 and 6, or over 6, respectively. These three classes mean, practically, pebbles composed of fresh rock of igneous origin, fresh limestone, and weathered pebbles of both types.



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TABLE III.  
Results of Tests on Gravel Samples.

Owner and Location.	1 Fine- ness factor.	2 Per cent of clay and silt.	3 Colour test.	4 Mortars: 1 cement, 3 sand.					Remarks.
				1 Per cent of water used.	Tensile strength, lbs. per sq. in.		Compressive strength, lbs. per sq. in.		
					7 days.	28 days.	7 days.	28 days.	
Sand pit, E. of Lyn.....	1.4	1.6	0	16	123	231	995	1,810	
Donovan Bros.' pit, E. of Escott .....	3.5		0	10	406	545	3,800	5,850	Clean sand.
Donovan Bros.' pit, E. of Escott .....	1.8		0	15	176	252	1,500	2,490	Clean, sharp sand.
L. Donovan's pit, S. of Es- cott.....	3.0		0	11	344	437	3,610	4,525	
J. Nadeau's pit, N. of Gana- noque .....	2.6		0	11	224	339	2,240	3,185	Clean sand.
J. Nadeau's pit, N. of Gana- noque .....	1.8		100	16	143	345	1,380	2,350	Carrying some mica.
J. Nadeau's pit, N. of Gana- noque .....	3.1	5.2	0	11	310	388	2,800	3,900	Iron oxide in sand.
R. Jackson's pit, W. of Gana- noque .....	2.3		0	12	159	210	1,530	1,870	Clean, sharp sand.
W. McFadden's pit, Pitts- ferry.....	2.6	12.6	200	12	163	229	2,350	3,380	Loam and iron oxide in sand.
W. McFadden's pit, Pitts- ferry.....	2.8		50	11	235	366	1,850	3,120	Clean, reddish sand.

<sup>1</sup>Design of concrete mixture. D. A. Abrams. Bul. No. 1, Structural Materials Research Laboratory, Lewis Inst., Chicago, April, 1919.

<sup>2</sup>Per cent of material passing 200-mesh.

<sup>3</sup>Colorometric test for organic impurities in sand. D. A. Abrams. Circular No. 1, Structural Materials Research Laboratory, Lewis Inst., Chicago, February, 1917.

<sup>4</sup>Ottawa standard sand, strength of 1:3 mortar: tensile 7 days— 174 lbs. per sq. in.

“ 28 days— 292 “  
Compressive 7 days—1,540 “  
“ 28 days—2,275 “



## DIVISION OF CHEMISTRY.

F. G. WAIT, *Chief of Division.*

The following is a general statement and detailed record of the various assays and analyses performed in the Chemical Laboratory situated in the main office building of the Mines Branch, Sussex street, Ottawa, during the calendar year 1919.

Assays for Gold, Silver, and Platinum: from the undermentioned localities:—

### (a) *British Columbia.*

- i. Within five miles of Usk, via Grand Trunk Pacific, near the Skeena river, 3 samples.
- ii. The Gold Range near the Big Ledge zinc property, about 16 miles northwest of Nakusp.
- iii. Mamette Lake location, Merritt district.
- iv. Average sample of a dump on galena claims, 40 miles northeast of Quesnel.
- v. From the property of Mr. E. Mobbs, lying close to a road running from Kootenay lake to Trout lake.
- vi. Capella claim and Sweetwater claim, Slocan district, 2 samples.
- vii. Stouts gulch, vicinity of Barkerville, Cariboo district. From a 43-foot wide vein of quartz in the hydraulic pit.
- viii. Nechako mines, Stony creek.
- ix. Ledge on Kennedy creek, north fork of Kettle river, 20 miles north of Grand Forks, B.C.
- x. Eden claims on Fraser river, 50 miles north of Fort George.
  - a. Sample taken across lead, Willow creek.
  - b. Sample taken across lens, Willow creek.
- xi. Bridge River area:—
  - From the Lorne mine, 20 samples.
  - From the Pioneer mine, 4 samples.
  - From Copper mountain, 1 sample.
  - From Anderson lake, Creagh's claim, 1 sample.
  - From Kinder's claim, and Maud S. claim, 1 sample from each.
- xii. Ferguson (Kootenay) Parrsboro claim, 2 samples.
- xiii. Britton mountain, 8½ miles above Tulameen.
- xiv. Shore of Barclay sound—precise location not specified.

### (b) *Yukon.*

Dublin gulch, 11 samples.

### (c) *Manitoba.*

Cross lake, Hire's vein, 2 samples.  
 Knee lake, Motherlode mineral claim.  
 " " Painkiller point.  
 Nickel lake, shore of.

### (d) *Northwest Territories.*

10 miles south of Pine point, Great Slave lake.



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(e) *Ontario.*

Algoma on the line of the Algoma Central and Hudson Bay railway.

- i. In township XXV, range 13.
- ii. One mile east of mileage 171, from pyrite range.
- iii. Two miles east of Pine lake, near Goudreau.

Lanark county, North Elmsley township, lot 28, concession IX.

Renfrew county, McNab township, lot 9, concession IX.

Sudbury district, Norman township, lot 4, concession IV.

Thunder Bay district—

Dorion township, shore of Black bay.

“ “ Lebel claim, 2 samples.

Gorman township, northeast corner; south shore of Wasp lake, Dafoe claim.

Stirling township, lot 2, concession VI.

Black bay, southeast shore of.

Cascade creek.

Port Arthur, vicinity of, W. R. Brown's claim.

Puff island.

Red Rock, vicinity of, 2 samples.

Sturgeon bay, west side of.

Timiskaming district—

Kirkland Lake Mining Company's property.

Maisonville township, shore of Wolf lake.

Morrisette township, near Goodfish lake, 4 samples.

Munro township, lot 8, concession I.

McIlroy township, from a point 9 miles east of Dane.

Timagami reserve, Sandy inlet, 2 samples.

Tudhope township, precise locality not stated.

(f) *Quebec.*

Beauce county, one mile southeast of the junction of the southeast and north branches of Gilbert river.

Labelle county, Buckingham township, lot 21, range IV.

Pontiac county, North Onslow township, lot 18, range VIII.

Ungava district, eight samples from unspecified localities in the northern part of the district.

(g) *New Brunswick.*

Albert county, vicinity of New Ireland, parish of Alma.

“ “ Albert mines, shale from, 9 samples.

Unspecified localities, 47 samples.

**Barite.**

*Ontario*—Timiskaming district, Langmuir township, from the Premier-Langmuir mine near Connaught station.

**Carbonaceous rocks: for carbon content.—**

*British Columbia*—Fraser canyon, and two samples from undesignated localities, one in Quebec and one in Nova Scotia.

**Chrome iron ore.**

*Ontario*—Timiskaming district, Rheame township, lot 10, concession V.



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**Copper ores.**

*Ontario*—not precisely stated, but from the Keeweenawan series of rocks, north and east of Port Arthur, 3 samples.

*Quebec*—Ungava 4 samples from unspecified localities in the northern section of the district.

**Feldspar.**

*Ontario*—Lanark county, South Sherbrooke township, lot 13, concession V. Complete analysis.

**Hydromagnesite.**

*British Columbia*—

1. From a point  $\frac{3}{4}$  of a mile northeast of the village of Clinton.
2. Watson lake, a point 1,500 feet south of, which lies  $1\frac{1}{2}$  miles west of Cariboo road, and south of 105-mile House, 2 samples.
3. Meadow lake, one mile east of the east end, situated 16 miles west by north of 70-mile House in Cariboo road, 2 samples.
- 3a. From a small deposit, 1 mile northwest of Watson lake, near the corral gate.
4. A point at the junction of the north and south forks of Reske creek, west of Chimney Creek bridge on Fraser river.

**Iron ores.**

- (a) *Ontario*—Frontenac county, Robertsville.
- (b) *Quebec*—Ottawa county, Hull township, lot 13, C, range VII, Lawless mine.
- (c) *Ungava*.—2 samples from undersigned localities in the northern part of the district.
- (d) *Northwest Territory*—20 miles from Fort Wrigley in the Mackenzie River region.

**Pig-iron and steel.**

Seventy samples were submitted to partial analysis, determinations of the carbon content of each being required by the Department of Customs for tariff classification purposes.

**Lead ores.**

- (a) *Yukon Territory*—Lookout mountain, Mayo district.
- (b) *Northwest Territory*—10 miles south of Pine point, Great Slave lake.
- (c) *British Columbia*—a galena claim 40 miles northeast of Quesnel, Cariboo district. From E. Mobb's property, along Kootenay and Trout Lake road.
- (d) *Ontario*—Timiskaming district, Maisonsville district, Wolf lake.

**Limestones.**

(a) *British Columbia*—2 samples from a spring deposit near 141-mile House, Cariboo road.

(b) *Ontario*—

i. Hastings county:—

- (a) Dungannon township, Ontario Marble Co's quarry, near L'Amable.
- (b) Huntingdon township, Gibson quarry at Crookston.
- (c) Madoc township, lot 16, concession V.
- (d) Marmora township, lots 7 and 8, concession IV.



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## ii. Lanark county:—

Bathurst township, lot 3, concession IV.  
North Elmsley township, near Otty lake.

## iii. Lincoln county:—

Gibson's quarry at Beamsville.

## iv. Ontario county:—

Thorah township, lot 22, concession I.

## v. Stormont county:—

Finch township, lot 8, concession IX.

## vi. Wellington county:—

Puslinch township, J. L. Maloney's quarry, one-half mile west of  
Puslinch station.

(c) *Quebec*—

## i. Joliette county:—

From a quarry on the property of Mme. O. Ferland, 3 miles east of  
Ste. Elizabeth.

## ii. Missisquoi county:—

Lot 4 west, Parish of St. Armand, 2 samples.

(d) *New Brunswick*—

Moncton map area—one sample from Boyd creek, and one from Windsor  
quarry.

(e) *Nova Scotia*—

## Cape Breton county:—

From a quarry at Eskasoni, Georges river.

**Manganese ores.**

*British Columbia*—11 miles southwest of Clinton

*Quebec*—Arthabaska county, Chester township, precise locality not stated.

*Nova Scotia*—Colchester county, Clifton, Black Rock, Thos. H. Donaldson's  
property.

**Mercury ores.**

*British Columbia*—one-half mile from the mouth of a small creek which enters  
Sechart channel, Barclay sound, just east of Sechart whaling station.

**Nickel ore.**

A pyritiferous schist from a point two miles southeast of Dartmouth, *Nova  
Scotia*, and two samples from undesignated localities.

**Potash-bearing materials.**

## (a) Salt—crude sodium chloride:

Four samples, from the salt deposit at Malagash, Cumberland county, *Nova  
Scotia*.

(b) Cement and the raw material of the same from the Canada Cement Co's  
works at Winnipeg, Belleville, and Montreal, 8 samples.(c) Feldspar, one sample of orthoclase from lot 13, concession V, South Sher-  
brooke, Lanark county, *Ontario*.



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**Pyrite.***Ontario—**Algoma district:—*

From a pit of so-called "natural fines", on M.C.A.C. 44, near Goudreau.  
One mile east of mileage 171, Algoma Central and Hudson Bay railway.

*Hastings county:—**Madoc township:—*

- i. Lot 18, concession II, Morrison's property.
- ii. Lot 18, concession V, Eldorado copper mine.
- iii. Lot 12, concession VI.
- iv. Lot 25, concession VI. Bannockburn mine.
- v. Lot 6, concession VII.
- vi. Lot 9, concession X.
- vii. Craig mine, 2 samples.

*Kenora district:—*

Eagle lake, Net island.

*Nipissing district:—*

- i. Mining claim, W.D. 357, 2 samples.
- ii. Cassell township, Net lake, east side, Mandy's claim.

*Rainy River district:—*

Nickel lake, near Fort Frances, Preston claim.

*Sudbury district:—*

- i. Norman township, lot 2, concession VI, 2 samples.
- ii. Unsurveyed territory, south of townships of Dale and McOwen, 2 samples.

*Thunder Bay district:—*

- i. M.L. 2831, near Schreiber.
- ii. Vicinity of Mokeman, near Port Arthur.
- iii. Hornick's claim, near Stainton station, Canadian Northern railway.
- iv. Atikokan iron mines, 2 samples.

*Timiskaming district:—*

- i. Boston township, M.R. 14, Kirkegarde's claim.
- ii. Eby township, lot 2, concession III, Swastika.
- iii. Tisdale township, Moyer's Veteran claim, Porcupine.
- iv. Tisdale township, Wright's claim, Bob's lake, 2 samples.

**Quartz, quartzites, sandstones and silica sands, for industrial purposes.***Manitoba—*

Big island, Lake Winnipeg, 2 samples.

*Ontario—**Algoma:—*

Near Bellevue, on Algoma Central Railway, in Vankoughnet township.

*Carleton:—*

Nepean sandstone quarries at South March.

*Frontenac:—*

Portland township, west half lot 16, concession XI.

" " lot 16, concession X.

Loughboro " lot 10, concession VII.



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## Haldimand:—

Cayuga township, Nelles Corners, Oneida Lime Co's property.

(a) Crushed and washed sample.

(b) Washings from sandstone.

Oneida township, north end of the southwest quarter of lot 49, concession I.

“ “ south quarter of lot 47, concession I, and northwest eighth part of lot 46, concession I, an average sample of two deposits.

## Halton:—

Nassagaweya township, lot 3, concession VII, Robinson's quarry.

## Hastings:—

Dungannon township, lot 22, concession II, near Turiff station, Canadian Northern railway.

Elzevir township, lot 3, concession IV, from the east bank of Moira river, north of Actinolite, Ont.

Madoc township, east half of lot 5, concession X.

## Lanark:—

North Elmsley township, one mile and a half east of Perth, on the north bank of the Tay canal. J. Menzies' property.

Lavant township, one mile and a half northwest of Clyde Forks. Property of T. B. Caldwell.

a. From north half.

b. From south half.

South Sherbrooke township, lots 12 and 13, concession VIII.

South Sherbrooke township, lot 6, concession VII, Rinaldo McConnell's property.

South Sherbrooke township, south half of lot 9, concession IV.

## Leeds:—

Elizabethtown township.

i. South half 22, concession II.

ii. Bresee's property, 2½ miles west of Brockville.

## Sudbury district:—

From mileage 65 on Algoma Eastern railway.

## Thunder Bay district:—

i. Malcolm Watty's property on Wolfe river, seven miles north of Dorion station.

ii. Same locality as preceding, material found imbedded with dolomite and sandstones.

iii. Simpson island, Lake Superior.

iv. Submitted by Mr. Marks, Port Arthur; said to be from Thunder Bay district.

v. Quarry near entrance to Black bay, W. Long. 86/31/05, N. Lat. 48/33/10.

## Welland:—

Bertie township, Lake Erie front, lot 13, Flint.

## Quebec—

Beauharnois. Melocheville. From the Montreal Sand and Gravel Co's quarry.

## Chateauguay:—

i. Russelltown, lot 6, range III. From the farm of G. H. Brooke.

ii. Two and a half miles west of Russelltown, on the road to Stockwell. From the farm of B. Roberts.



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**Hull:—**

- i. Quartz from the stockpile of the Electric Reduction Co. at Buckingham. Found in association with the feldspar in the Lièvre River district.
- ii. Sandstone from Bilsky's property at East Templeton.

**Labelle:—**

St. Rémi d'Amherst. Quartzite from the Canadian China Clay Co's property. Same locality as preceding. Washed sand.

**Missisquoi:—**

One mile east of St. Armand station, on road to Mitchell's Corners. Sandstone.

**Soulanges:—**

- i. Cascades point, Cascades Silica Products Co's quarry. Crushed sandstone.
- ii. Same locality as preceding. Washed silica sand.

**Timiskaming:—**

Crushed sandstone from the Quebec shore of Lake Timiskaming, opposite Haileybury, Ont.

**Two Mountains:—**

St. Canute. Sandstone from the Stinson-Reeb quarry.

**New Brunswick:—****Moncton Map Area:—**

Sample of sandstone from an undefined locality, submitted by Mr. W. J. Wright of the Geological Survey.

**St. John county:—**

Sandstone from a deposit one-half mile north of Torryburn station.

**Nova Scotia:—****Cape Breton county:—**

Quartzite from the stockpile of the Dominion Iron and Steel Co. at Sydney. Locality of its occurrence, not stated.

**Inverness county:—**

Whycocomagh. Quartzite.

**Queen's county:—**

Port Mouton,—

- i. Silica sand from Summerville beach.
- ii. Silica sand from the southwest beach.

**Shelburne county:—**

Barrington bay, silica sand from beach.

**Salt: crude sodium chloride.****Nova Scotia—Cumberland county:—**

Malagash salt deposit, 7 miles from Malagash station, 4 samples.

**Natural waters.****British Columbia:—**

Saline water from a soda lake in Cariboo district, near 70-mile House.

**Ontario:—**

From a spring on the mainland of Thunder cape, one-half mile east of lake Marie Louise, and directly opposite Silver islet.

**Nova Scotia—Plumweseep; and**

five other samples, the locality of which was not stated.



SESSIONAL PAPER No. 26a

## DIVISION OF MINERAL RESOURCES AND STATISTICS.

JOHN McLEISH, *Chief of the Division.*

## I

## GENERAL REVIEW.

The staff of this division has, during 1919, been as usual, chiefly occupied with the duties involved in the collection of statistics and of information respecting the mining and metallurgical industries of Canada, the preparation of annual reports on mineral production, trade and consumption, supplemented by the preparation of numerous special memoranda respecting the occurrences of mineral resources and their utilization.

The annual report on mineral production is designed to present not only a complete annual inventory of the mining and metallurgical industries of Canada, but includes for each mineral product a discussion of trade conditions, imports, exports, domestic consumption, prices, and, from time to time, descriptions of methods of preparation of ores and mineral products, their uses and markets.

The report is based upon statistical data collected by correspondence from some 3,800 smelter, mine, and quarry operators throughout the Dominion, supplemented by records of ore and mineral shipments furnished by railway companies, by records of ore receipts furnished by smelting companies both in Canada and in the United States, and by other data having a direct bearing on mineral production or on mineral consumption.

This series of annual records dates from 1886 and it has been the practice from the beginning to anticipate the complete report, the publication of which must necessarily, for various reasons, be delayed until late in the year, by the issue, two months after the close of the year covered, of a "Preliminary Report on the Mineral Production of Canada." While subject to revision, the statistical records of this preliminary report, particularly in recent years, have been found in most products to approximate very closely indeed to the final records.

Since 1907 the publication of the complete annual report has been preceded by the advance publication of separate chapters, as the compilation was completed, on the more important mineral products, these advance chapters being reprinted, and included in the annual report.

Thus, not only have the final and complete statistical records been available more promptly, but the publication of separate parts has made the data more readily available to those interested in particular subjects.

During the last three years of the war the annual collection of production statistics was supplemented by monthly, or quarterly records of a number of the more important mineral products, particularly those the production of which became of first importance in the successful prosecution of the war. These included monthly records of the production of pig-iron and steel, of chromite, coal, pyrites, sulphuric acid, etc. The data thus obtained were furnished to the Fuel Controller, the Mineral Resources Commission, the War Trade Board, and other interested departments. In addition to the statistical records, numerous special memoranda and reports were prepared for the information of war boards and commissions, as well as for the Imperial and United States Governments, on the possible and probable production in Canada of many "war minerals."



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During the few months immediately following the tenth of March, 1919, the greater part of the time of the chief of this division was taken up with the duties of the acting directorship of the Mines Branch. On this account, and in order to facilitate the more prompt publication of the final mineral production record, the annual report on mineral production in 1918, was submitted for publication in greatly abbreviated form.

Separate reports dealing more completely with the production of the metals, and of coal and coke, were completed and published as usual, but were not reprinted in the annual report for the year.

In the completion of the final reports on mineral production Mr. A. Buisson has again compiled the statistics with respect to metals and metallic ores, and has prepared the report on production of gold, silver, copper, lead, nickel, silver, zinc, and other miscellaneous metals. He has also revised the list of "Metal Mines."

The report on production of iron and steel in 1918 was compiled by the writer.

Mr. Casey has, as usual, compiled all the statistics of the production of non-metalliferous products and structural materials, as well as the records of imports of mineral products, and has prepared for printing the various lists of mine and quarry operators, with the exception of the "Metal Mines" and "Metallurgical Works" lists.

The following reports and lists were completed during the year and submitted for printing on the dates indicated:—

#### *Reports—*

- Preliminary Report on the Mineral Production of Canada, during the calendar year 1918—February 27, 1919.
- Annual Report on the Mineral Production of Canada, during the calendar year 1918—September 5, 1919.
- The Production of Copper, Gold, Lead, Nickel, Silver, Zinc and Other Metals in Canada, during the calendar year 1918—September 19, 1919.
- The Production of Coal and Coke in Canada, during the calendar year 1918—November 11, 1919.
- The Production of Iron and Steel in Canada, during the calendar year 1918—December 23, 1919.

#### *List of Mine Operators—*

- Petroleum and Natural Gas Wells, including a list of Petroleum Refineries—August 23, 1919.
- Coal Mine Operators in Canada—September 17, 1919.
- Non-Metal Mines in Canada (other than coal mines, oil and gas wells, clay, and stone quarries, etc.)—October 2, 1919.
- Cement Mills and Sand-Lime Brick Plants—October 6, 1919.
- Manufacturers of Clay Products—October 22, 1919.
- Lime Kilns in Canada—October 24, 1919.
- Stone Quarry Operators in Canada—October 31, 1919.
- Operators of Sand and Gravel Pits—November 11, 1919.

#### CO-OPERATION WITH THE DOMINION BUREAU OF STATISTICS IN THE COLLECTION OF MINERAL PRODUCTION STATISTICS FOR 1917, 1918, AND 1919.

Pursuant to an arrangement entered into with the Dominion Bureau of Statistics the complete files of statistical production records for the years 1917 and 1918, collected by this division, were made available to the Dominion Bureau of Statistics of the Department of Trade and Commerce. The same co-operation is being continued in respect to the mineral production records for the calendar year 1919.

## II.

### MINERAL RESOURCE INDEX AND RECORDS.

This division has since its organization in 1886 maintained a card index to mineral occurrences and resources, and a file of records of mines and mining works in Canada.



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The mineral resource index comprises a card index system of references to Canadian mineral occurrences contained in the reports of the Dominion Department of Mines; the various provincial mines reports, and the proceedings and transactions of mining, geological and other scientific societies. This index is arranged under the headings of the metals and non-metallic minerals of economic importance.

As a considerable amount of mining and geological literature is annually published, a good deal of time is required to keep the index up to date; and during the past year or two the growing demands of our mining statistical work have occupied the entire attention of the staff to the exclusion of this most valuable and essential work.

The mineral resources record file is an amplification of the card index mentioned above and is arranged in the same general order. Instead of references, however, it is designed to contain actual records of mining works and mining development obtained from all sources, such as through correspondence, field investigations by the staff of this division, reports on mine development collected and prepared by the field staff of the Geological Survey and Mines Branch, papers and data extracted from the scientific journals and mining press. It provides a convenient and systematic method for the filing of mining plans, photographic prints, annual reports of mining companies, and in fact all classes of records pertaining to mining work.

This record has never had the attention which its great importance deserves, and has been kept up only to the extent permitted by an already over-worked staff. Its proper development will require the services of fully qualified technical engineers.

The great importance of an inventory of Canadian mineral resources was actually realized during the war, and the Munition Resources Commission undertook to card index as completely as possible those mineral resources of the Dominion, particularly required for munition purposes. This work was carried on with the assistance of the staff of the Department of Mines and in close co-operation with this division. The card reference system already developed was used as the basis for a much more comprehensive and inclusive system of inventory cards which not only furnished the references to sources of available information but contained also a synopsis of the essential and useful information respecting each individual mine or resource catalogued.

A complete detailed description of this index has been published in the final report of the Munition Resources Commission, pages 204-208.

On the dissolution of the Mineral Resources Commission this inventory, so far as it had been compiled, together with a complete set of cards, guides, etc., was turned over to this division. As soon as the necessary assistance can be provided the work should be continued and amplified.

### III.

#### FIELD WORK.

The writer attended the annual meeting of the American Institute of Mining Engineers held in New York in February, and the annual convention of the Canadian Mining Institute held in Montreal during the first week in March, where as usual the preliminary report on the mineral production of Canada was presented.

The Department of Mines shared with the Water Powers Branch of the Interior Department a booth space at the Fifth National Exposition of Chemical Industries held at Chicago, September 22-27, for the purpose of furnishing information respecting the mines and mineral resources and industries of Canada. The mines information bureau was placed under my direction, assisted by Mr. L. L. Bolton.



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From Chicago I proceeded to Pittsburgh and attended as one of the official representatives of the Department of Mines and also of the Canadian Mining Institute, the formal dedication of the new laboratories, Pittsburgh experiment station of the United States Bureau of Mines.

Mr. A. Buisson attended at the Canadian Mining Institute annual convention in Montreal in March, and in September and October visited a number of the mining districts in Northern Ontario and Quebec, and with respect to the latter reports as follows:—

“Following instructions from Mr. McLeish, the writer left Ottawa September 10, 1919, for a visit to the different mining camps in the Timiskaming district of Ontario, and also to Amos, Notre Dame des Anges, and Shawinigan Falls, Que.

“The labour troubles which occurred in the summer and fall of 1919 were the cause of many properties closing down. When the writer visited the Kirkland Lake district the strike of the miners had not yet been settled and all the mines were idle. New districts such as Boston Creek which had started the season most favourably were all badly hit by the effect of the strike and very little work was being done.

“The strike in Cobalt was settled towards the middle of September, but most properties could not resume operations on a normal scale until October.

“The scarcity of labour, and the high costs of labour and supplies were a serious handicap in the Porcupine district, so that the only producers in October were the Hollinger, Dome, McIntyre, and Davidson mines.

“A brief visit was made to Amos, Quebec, but the bad weather prevented any visit to the camp, which is about 40 miles south of the town of Amos. Professor Mailhot of the École Polytechnique spent the summer in this district, and his report will appear in the Provincial Bureau of Mines Report for 1919.

“A visit was made to the zinc-lead mines of Notre Dame des Anges, Quebec, and a day spent at Shawinigan Falls, visiting some of the metallurgical plants.

“A brief stop was made in Montreal to interview the officers of some of the companies operating in the province of Quebec.

“All told, the trip lasted one month, and much information was gathered in connexion with the different companies operating in the districts visited, and about the metallurgical processes in use.”

#### IV.

#### MINERAL PRODUCTION DURING 1919.

The mineral production of Canada during the calendar year 1919 has as usual been the subject of the preliminary report published February 28, 1920. As the revised figures are now available they are presented in the following table:—

In an analysis of the mineral production during 1919 it was stated in the preliminary report, and the comment applies equally to the revised record, that:—

“The wide range of prices through which many metals and mineral products have passed during the past five years, and the continuation of high prices for many products, have of course resulted in greatly increasing the total value of the mineral production, even when the actual quantities of metals or minerals obtained might be decreasing. It is evident that less importance should be given to comparisons in values and that more stress should be laid upon quantity comparisons. This may be readily done with individual products, but appears less feasible when dealing with totals of a great variety of products.”



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"Just as the declaration of war in 1914 was followed by a short period of industrial dislocation before the activity necessitated by the war's requirements became fully launched, so, following the cessation of hostilities, there has been an interregnum, or transition period, during which the war's demands are being replaced by the legitimate requirements of peace industries and the demands of reconstruction."

"The difficulties of making these readjustments have been aggravated by social upheavals and strikes."

"The net falling off in mineral production in 1919 has been a mean between a large decrease in the production of metals, coal, and many "war minerals" such as chromite, graphite, magnesite, pyrites, etc., on the one hand, and large increases in the production of structural materials such as cement, clay products, lime, and building stone, and also of asbestos, gypsum, and salt."

The metallic production in 1918 was valued at \$114,549,152, which fell in 1919 to \$73,262,793, a decrease of \$41,286,359 or 36 per cent. Gold is the only metal of which there was an increased production. The falling off in the quantities of other metals varied from 8.2 per cent in zinc to nearly 52 per cent in nickel.

The total value of the non-metallic production, including clay and quarry products, in 1919 was \$103,423,597 as compared with \$95,752,745 in 1918, showing an increase of \$7,670,852, or 8 per cent. The cement, clay, and stone products alone were valued at \$27,421,510 as against \$19,130,799 in 1918, an increase of \$8,290,711, or over 43 per cent. The total value of non-metallic products other than structural materials was \$76,002,087 as against \$77,621,946, a decrease of \$1,619,859, or 2.1 per cent.

## V.

## MINERAL PRODUCTION OF CANADA DURING 1919.

(Revised Statistics.)

	Quantity.	Value.
<i>Metallic.</i>		\$
Antimony ore..... <sup>1</sup> Tons.	Nil.	Nil.
Antimony refined..... <sup>1</sup> Lbs.	Nil.	Nil.
Cobalt, metallic and contained in oxide, etc., at \$2.50 per lb.....	530,371	1,325,928
Copper, value at 18.691 c. per lb.....	75,053,581	14,028,265
Gold, at \$20.671834 per oz..... <sup>1</sup> Ozs.	766,764	15,850,423
Iron, pig, from Canadian ore, (a)..... <sup>1</sup> Tons.	38,457	899,406
Iron ore sold for export, (b)..... <sup>1</sup> "	5,883	46,525
Lead, value at 6.966c. per lb..... <sup>1</sup> Lbs.	43,827,699	3,053,037
Molybdenite..... <sup>1</sup> "	83,002	69,203
Nickel, value at 40c. per lb..... <sup>1</sup> "	44,544,883	17,817,953
Platinum and palladium, (c)..... <sup>1</sup> Ozs.	110	7,131
Silver, value at 111.122c. per oz..... <sup>1</sup> "	16,020,657	17,802,474
Zinc, value at 7.338c. per lb..... <sup>1</sup> Lbs.	32,194,707	2,362,448
Total metallic.....		73,262,793
<i>Non-Metallic.</i>		
Actinolite..... <sup>1</sup> Tons	80	880
Arsenic, white and in ore..... <sup>1</sup> "	3,389	509,924
Asbestos..... <sup>1</sup> "	136,765	10,909,452
Asbestic..... <sup>1</sup> "	22,471	65,917
Chromite..... <sup>1</sup> "	8,541	228,898
Coal..... <sup>1</sup> "	13,681,218	54,413,349

<sup>1</sup>Short tons throughout.



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MINERAL PRODUCTION OF CANADA DURING 1919—*Concluded.*  
(Revised Statistics.)

		Quantity.	Value.
Feldspar.....	Tons.	14,679	\$ 86,231
Fluorspar.....	"	5,063	97,837
Graphite.....	"	1,360	100,221
Graphite, (artificial).....	"	179	
Grindstones.....	"	2,020	60,516
Gypsum.....	"	299,063	1,215,287
Magnesite.....	"	11,273	328,465
Magnesium sulphate.....	"	738	9,115
Manganese.....	"	661	14,159
Mica.....	"	2,754	273,788
Mineral pigments:—			
Barytes.....	"	468	8,154
Oxides.....	"	11,862	113,427
Mineral water.....	"		71,015
Natural gas.....	M. cu. ft.	19,937,769	4,176,037
Peat.....	Tons.	986	6,561
Petroleum.....	Brls.	240,466	736,324
Phosphate.....	Tons.	24	331
Pyrites.....	"	176,487	522,704
Quartz.....	"	94,991	527,635
Salt.....	"	148,301	1,397,929
Talc.....	"	18,642	116,295
Tripolite.....	"	565	11,300
Strontium.....	"	48	336
Total non-metallic.....			76,002,087
<i>Structural Materials and Clay Products.</i>			
Cement, Portland.....	Brls.	4,995,257	9,802,433
Clay products:—(\$7,906,366)—			
Brick, common.....	No.	291,469,996	3,850,219
Brick, pressed.....	"	74,423,703	1,304,162
Brick, paving.....	"		
Brick, moulded and ornamental.....	"	364,682	10,175
Fireclay and fireclay products, (d).....			389,354
Fireproofing.....	Tons	41,406	345,382
Hollow building blocks.....	No.	1,984,848	76,673
Kaolin.....	Tons	759	13,744
Pottery, (d).....			185,474
Sewer pipe.....	Tons	62,821	1,074,146
Terra cotta.....			40,527
Tile, drain.....	No.	20,078,000	616,510
Lime.....	Bush	7,147,504	2,310,607
Sand-lime brick.....	No.	33,553,699	484,854
Sand and gravel.....	Tons	10,364,481	2,680,460
Slate.....	Sq.	1,632	10,853
Stone:—(\$4,225,937)			
Granite.....			850,563
Limestone.....			3,074,815
Marble.....			213,982
Sandstone.....			86,577
Total structural.....			27,421,510
Grand Total.....			176,686,390

(a) The figures given represent only the quantity of pig-iron made in Canada, estimated as derived from Canadian ore. The total production of blast furnace pig-iron was 910,080 tons, valued at \$24,245,792.

(b) The total shipments of iron ore from Canadian mines were 195,970 tons, valued at \$687,386.

(c) The figure given represents only the reported recovery of metals of the platinum group in Canada. There is in addition a considerable recovery of these metals in New Jersey and in Wales from the nickel-copper mattes produced in the Sudbury District, of which only a partial record is available.

(d) There is also a considerable production from imported clays. The total values of the production from both domestic and imported clays were: Fireclay products \$453,487; Pottery, \$890,320.



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## DRAUGHTING DIVISION.

H. E. BAINE, *Chief Draughtsman.*

The work of this division for the past year consisted in the preparation of magnetometric maps, and of various mechanical drawings, diagrams, charts, etc., and the preparing and printing of maps for the Canadian Munition Resources Commission.

The following is a list of maps published during the calendar year 1919:—

- No. 513. Graphite occurrences in Bedford, Loughborough, Burgess, and Elmsley townships, Ontario.  
Scale: 3.95 miles to one inch.
- No. 514. Graphite occurrences in Monmouth, Cardiff, Monteagle, and Dungannon townships, Ontario.  
Scale: 3.95 miles to one inch.
- No. 515. Graphite occurrences in Brougham and Blythfield townships, Ontario.  
Scale: 3.95 miles to one inch.
- No. 516. Graphite occurrences in Grenville and Wentworth townships, Quebec.  
Scale: 3.95 miles to one inch.
- No. 517. Graphite occurrences in Amherst township, Quebec.  
Scale: 3.95 miles to one inch.
- No. 518. Graphite occurrences in Buckingham and Lochaber townships, Quebec.  
Scale: 3.95 miles to one inch.
- No. 523. Gas and Oil Fields, and Pipe Lines in Southwestern Ontario.  
Scale: 15 miles to one inch.
- No. 524. Petroleum, Natural Gas, and Bituminous Sands in Western Canada.  
Scale: 200 miles to one inch.
- Main Gas Line, Bow island to Calgary, Alberta.  
Scale: 12½ miles to one inch.
- No. 526. Location of Natural Gas Wells in British Columbia.  
Scale: 35 miles to one inch.
- 227 mechanical drawings, diagrams, charts, and flow sheets.  
95 black and white prints.  
230 blue prints.

## Maps prepared for the Canadian Munition Resources Commission:—

British Columbia.. . . .	scale: 17½ miles to one inch.
Alberta.. . . .	" 17½ " " "
Saskatchewan.. . . .	" 17½ " " "
Manitoba.. . . .	" 17½ " " "
Ontario.. . . .	" 17½ " " "
Quebec.. . . .	" 17½ " " "
Prince Edward Island.. . . .	" 8 " " "



REPORT COVERING THE OPERATIONS OF THE DOMINION OF CANADA  
ASSAY OFFICE, VANCOUVER, B.C., DURING THE YEAR  
ENDING DECEMBER 31, 1919.

By G. MIDDLETON, *Manager.*

I have the honour to submit herewith report covering the operations of the Dominion of Canada Assay Office, Vancouver, B.C., for the calendar year ending December 31, 1919, accompanied by statements showing assayers' and melters' supplies on hand.

In the report for the previous calendar year, attention was drawn to the fact that on January 24, 1918, instructions were received to ship the gold bullion purchased by this office to the Royal Mint at Ottawa, but that the returns did not compare favourably with those of former years. As can be seen from this report, under the heading "Disbursements, Receipts, etc.," there is a considerable improvement, as it shows a difference in favour of this office of \$643.59, whereas last year's report showed a difference against this office of \$659.43. This is due in part to the change made at the mint in July, 1919, viz., in reporting our rough gold to the next quarter-thousandth part (as has been the custom at this office for several years) instead of to the next half-thousandth part. The abnormal rise in the price of silver between the time of the purchase of the bullion at this office and its arrival at the mint, also accounts for a part of the difference in favour of this office.

I.

There were 1,391 deposits of gold bullion received, melted, assayed and purchased; before disposing of same the small deposits were assembled and melted into large bars, which were also assayed. A total of 1,457 meltings and 1,457 assays were required in connexion with the purchase and disposal of the bullion, all assays being run in quadruplicate.

11,500 cupels of various sizes were made and 334 pounds of slag treated and the values contained in same recovered.

The aggregate weight of the gold bullion deposits before melting was 209,028.32 troy ounces, and after melting 205,949.72 troy ounces, showing a loss in melting of 1.4728 per cent. The loss in weight by assaying was 17.67 troy ounces, making the weight of bullion after melting and assaying 205,932.05 troy ounces, the average fineness of same being .827 $\frac{3}{4}$  gold and .135 silver.

The net value of the gold and silver contained in deposits was \$3,547,524.93 and was received from the following sources:—

Source.	Number of Deposits.	Weight.		Net Value.
		Before melting and assaying.	After melting and assaying.	
		(troy ozs.)	(troy ozs.)	\$    cts.
British Columbia.....	911	97,721.96	95,113.30	1,730,819 10
Yukon Territory.....	475	111,138.65	110,655.38	1,813,883 46
Alberta.....	1	9.80	9.39	161 93
Alaska.....	4	157.91	153.98	2,660 44
	1,391	209,028.32	205,932.05	3,547,524 93



## SESSIONAL PAPER No. 26a

## CREDITS AND DISBURSEMENTS FOR THE PURCHASE OF GOLD BULLION.

Unexpended balance, "Letters of Credit," January 1, 1919.. . . . .	\$ 346,708 25	
Credits established.. . . . .	3,250,000 00	
Balance written off at close of fiscal year, March 31, 1919.. . . . .		\$ 11,078 25
Disbursements.. . . . .		3,547,524 93
Unexpended balance, "Letters of Credit," December 31, 1919.. . . . .		38,105 07
	<u>\$3,596,708 25</u>	<u>\$3,596,708 25</u>

## DISBURSEMENTS AND RECEIPTS FOR THE PURCHASE AND SALE OF GOLD BULLION.

Value of bullion on hand, January 1, 1919.. . . . .	\$ 94,845 45	
Value of bullion shipped to Royal Mint, Ottawa, for which returns had not been received, January 1, 1919.. . . . .	111,643 54	
Disbursements for the purchase of bullion.. . . . .	3,547,524 93	
Receipts from bullion shipped to Royal Mint, Ottawa.. . . . .		\$3,153,396 94
Receipts from bullion sold for manufacturing purposes.. . . . .		336,473 18
Difference in favour of this office on bullion shipped to Royal Mint, Ottawa.. . . . .	643 59	
Difference in favour of this office on bullion sold for manufacturing purposes.. . . . .	8,966 33	
Value of bullion shipped to Royal Mint, Ottawa, for which returns have not yet been received.. . . . .		185,380 32
Value of bullion on hand, December 31, 1919.. . . . .		88,373 49
	<u>\$3,763,623 84</u>	<u>\$3,763,623 84</u>

## CONTINGENT ACCOUNT.

Unexpended balance, January 1, 1919.. . . . .	\$ 65 60	
Funds provided.. . . . .	2,825 00	
Amount remitted Receiver General at close of fiscal year, March 31, 1919.. . . . .		\$ 50 79
Expenditure.. . . . .		2,737 28
Unexpended balance, December 31, 1919.. . . . .		102 53
	<u>\$2,890 60</u>	<u>\$2,890 60</u>

## CONTINGENT EXPENDITURE.

Fuel (gas).. . . . .	\$ 715 12
Power.. . . . .	260 28
Express charges on bullion boxes (Ottawa to Vancouver).. . . . .	65 98
Electric vault protection.. . . . .	320 00
Postage and telegrams.. . . . .	65 60
Telephones.. . . . .	88 00
Expressage, freight, etc., on supplies.. . . . .	75 30
Assayers' and melters' supplies (purchased locally).. . . . .	887 76
Repairs to equipment.. . . . .	73 75
Sundries.. . . . .	185 49
	<u>\$2,737 28</u>

## PROCEEDS FROM SALE OF RESIDUES.

Residue recovered from slags, sweepings, etc.. . . . .	\$765 35
33 empty acid bottles.. . . . .	3 96
	<u>\$769 31</u>

## RESIDUES ON HAND, DECEMBER 31, 1919.

Residue recovered from slags, sweepings, etc.. . . . .	\$806 42
25 empty acid bottles.. . . . .	







SESSIONAL PAPER No. 26a

PLATINUM-BEARING ORES AND SANDS.

During the year 130 samples of ores and sands were assayed for platinum, details of which have been furnished from time to time on the form "Certificate of Assay." These assays were made free of charge.

The local expense account in connexion with this work and the refining and melting of platinum metals is subjoined:—

PLATINUM ORES ACCOUNT (INCLUDING THE ASSAYING OF PLATINUM-BEARING ORES AND SANDS AND THE REFINING AND MELTING OF PLATINUM.)

Unexpended balance, January 1, 1919.. . . .	\$ 17 80	
Funds provided.. . . .	240 00	
Amount remitted Receiver General at close of fiscal year, March 31.. . . .	.....	\$ 0 37
Expenditure.. . . .	.....	218 55
Unexpended balance, December 31, 1919.. . . .	.....	38 88
..	<u>\$257 80</u>	<u>\$257 80</u>

DETAILS OF EXPENDITURE SHOWN ON ABOVE STATEMENT.

Supplies.. . . .	\$152 15
Fuel.. . . .	41 50
Power.. . . .	19 00
Sundries.. . . .	2 90
	<u>\$218 55</u>

I am, Sir, your obedient servant,  
G. MIDDLETON,  
Manager.

G. MIDDLETON, Esq.,  
Manager, Dominion of Canada Assay Office,  
Vancouver B.C.

SIR,—I beg to report the following assayers' supplies on hand, as on December 31, 1919, viz:—

Silver nitrate crystals.. . . .	½ oz.
Lead foll, C.P.. . . .	10 lb.
" granulated, C.P.. . . .	½ "
Zinc, mossy, C.P.. . . .	2 "
Litharge.. . . .	6 "
Acid, nitric.. . . .	5 Winchesters.
" hydrochloric.. . . .	½ Winchester.
" oxalic.. . . .	2 lb.
Ammonia.. . . .	¾ Winchester.
Small clay crucibles.. . . .	96
Scorifiers, 2¼".. . . .	90
Cupels, all sizes.. . . .	10,900
Bone ash.. . . .	200 lb.
Muffles, spare.. . . .	105
Muffle furnace linings, spare.. . . .	1
" supports, spare.. . . .	20
" back stops, spare.. . . .	30
" plugs, spare.. . . .	4
" doors, spare.. . . .	10
Gold cornets.. . . .	12.24 oz.
Proof gold.. . . .	23 76 "
Silver.. . . .	275.00 "

Yours faithfully,  
A. KAYE,  
For Chief Assayer



10 GEORGE V, A. 1920

DOMINION OF CANADA ASSAY OFFICE,

VANCOUVER, B.C., January 5, 1920.

G. MIDDLETON, Esq.,

Manager, Dominion of Canada Assay Office,  
Vancouver, B.C.

SIR,—I beg to inform you that we had the following supplies on hand in the melting department on December 31, 1919, viz:—

6 sets of linings, with supports and covers complete, for No. 2 furnace.  
3 sets of linings, with supports and covers complete, for No. 4½ furnace.  
2 sets of linings, with supports and covers complete, for No. 7 furnace.  
4 muffles for No. 15 "Case" gas muffle furnace.  
8 graphite crucibles, No. 6.  
6 graphite crucibles, No. 14.  
3 graphite crucibles, No. 30.  
3 graphite crucibles, No. 40.  
2 graphite stirrers, No. OV12.  
50 pounds borax.  
75 pounds soda carb.  
80 pounds sodium nitrate.

Yours faithfully,

D. ROBINSON,  
*Chief Melter.*



SESSIONAL PAPER No. 26a

## LIST OF REPORTS, BULLETINS, ETC., PUBLISHED DURING THE YEAR 1919.

S. GROVES, *Editor Department of Mines.*

- 337. Catalogue of Mines Branch Publications (Tenth Edition). Published December 19, 1919.
- 497. Production of Copper, Gold, Lead, Silver, Zinc, etc., during the calendar year 1917. Bulletin on—by John McLeish, B.A. Published January 30, 1919.
- 498. Production of Iron and Steel, during the calendar year 1917. Bulletin on—by John McLeish, B.A. Published February 10, 1919.
- 499. General Summary of the Mineral Production, during the calendar year 1917. Bulletin on—by John McLeish, B.A. Published February 10, 1919.
- 500. Production of Cement, Lime, Clay Products, and other Structural Materials, during the calendar year 1917. Bulletin on—by John McLeish, B.A. Published February 10, 1919.
- 501. Production of Coal and Coke, during the calendar year 1917. Bulletin on—by John McLeish, B.A. Published February 10, 1919.
- 502. Economic Use of Coal for Steam-Raising and House Heating. Bulletin No. 28—by John Blizard, B.Sc. Published July 23, 1919.
- 504. The Mineral Production of Canada, during the calendar year 1917. Annual Report on—by John McLeish, B.A. Published June 28, 1919.
- 506. The Mineral Production of Canada, during the calendar year 1918. Preliminary Report on—by John McLeish, B.A. Published March 12, 1919.
- 507. Potash Recovery at Cement Plants. Bulletin No. 29—by Dr. A. W. G. Wilson. Published August 14, 1919.
- 519. Smelter Treatment Rates. (Report of the Committee of Investigation in the Matter of Tolls charged by the Consolidated Mining and Smelting Co. of Canada, Limited, at Trail, B.C.) Bulletin No. 30. Published December 10, 1919.
- 527. Production of Copper, Gold, Lead, Nickel, Silver, Zinc, etc., during the calendar year 1918. Bulletin on—by John McLeish, B.A. Published December 19, 1919.
- 528. Production of Coal and Coke, during the calendar year 1918. Bulletin on—by John McLeish, B.A. Published December 24, 1919.

**List of Mine Operators—**

- List of Coal Mine Operators in Canada.
- List of Mines in Canada (other than Metal Mines, Coal Mines, Stone Quarries, Clay Plants, etc.).
- List of Metal Mines in Canada.
- List of Stone Quarries in Canada.
- List of Cement Mills.
- List of Sand and Gravel Deposits.
- List of Petroleum and Natural Gas Wells.
- List of Manufacturers of Clay Products.

## FRENCH TRANSLATIONS.

JOBSON PARADIS, *Acting Chief of Publishing and Translation Division.*

- 494. Mines Branch Summary Report for 1917. Published May 19, 1919.
- 505. The Mineral Production of Canada, during calendar year 1917. Annual Report—by John McLeish, B.A. Published September 17, 1919.







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